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A Virus Disease of the European Pine Sawfly, *Neodiprion sertifer* (Geoffr.)[1]

By F. T. Bird and M. M. Whalen

Escherich (7) was the first to report a polyhedral virus disease affecting the European pine sawfly, *Neodiprion sertifer* (Geoffr.). Later Forsslund (8) observed that populations of this insect in Sweden were controlled by a virus disease. In 1948, H. S. Hanson, Entomologist of the Forestry Commission, England, observed mortality among *N. sertifer* in England which was due to a polyhedral virus disease (10). In 1949 virus-killed larvae collected in Sweden by Forsslund, were sent to the Laboratory of Insect Pathology, Sault Ste. Marie by G. R. Wyatt of this laboratory and the virus from these insects was propagated and used in the biological control of *N. sertifer* in southern Ontario (3, 5). This paper describes some aspects of the laboratory studies of the disease, namely: the infection process in cells susceptible to the virus, incubation period of the disease, and the isolation and electron microscope study of the causal agent.

Methods

Egg clusters of the European pine sawfly were collected from a disease-free infestation in southern Ontario early in December and were kept in cold storage (38°F.) until the latter part of January. They were then placed in lantern globe cages and kept at room temperature. The eggs hatched in about 10 days and the larvae were reared individually in vials on Scotch-pine foliage.

Polyhedral bodies were isolated by allowing virus-killed larvae to rot in water for several months. The polyhedra, which settled out and formed a white layer in the sediment on the bottom of the container, were purified by repeated centrifugation and washing and were suspended in sterile distilled water.

Virus concentrations were determined by using a Petroff-Hausser counting chamber with the dark-field microscope to estimate the number of polyhedra per millilitre of water.

Larvae were infected (a) by allowing them to feed on Scotch-pine foliage sprayed with a heavy suspension of partially purified polyhedra (50,000,000 polyhedra per millilitre of water), to produce the greatest mortality and to determine the rate at which larvae died when fed polyhedra in excess and (b) by feeding to them, after 24 hours without food, 0.5 microlitre droplets containing an estimated 5, 50, 500, and 5,000 purified polyhedra, to determine the median lethal dose.

The infection process was studied from sections of larvae killed at 24-hour intervals after they had been fed virus, fixed in Bouin's fluid, sectioned at four microns, and stained with Heidenhain's iron haematoxylin. At 12-hour intervals, frass pellets dropped by larvae were counted to determine when frass drop was affected by the disease.

Virus particles were isolated from purified polyhedra by a procedure similar to that described by Bergold (1). Purified polyhedra were dissolved in weak alkali (0.008 M Na_2C0_3 + 0.05 M NaC1). The virus particles, liberated from the polyhedra, were separated from dissolved protein by high speed centrifugation (12,000 r.p.m.).

1Contribution No. 91, Division of Forest Biology, Science Service, Department of Agriculture, Ottawa, Canada.

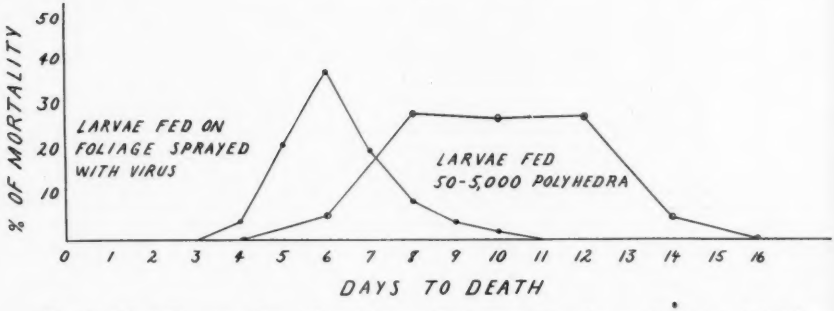

Fig. 1. Mortality rates from virus disease of 751 European pine sawfly larvae fed foliage sprayed with virus and of 241 larvae fed from 50 to 5,000 polyhedra.

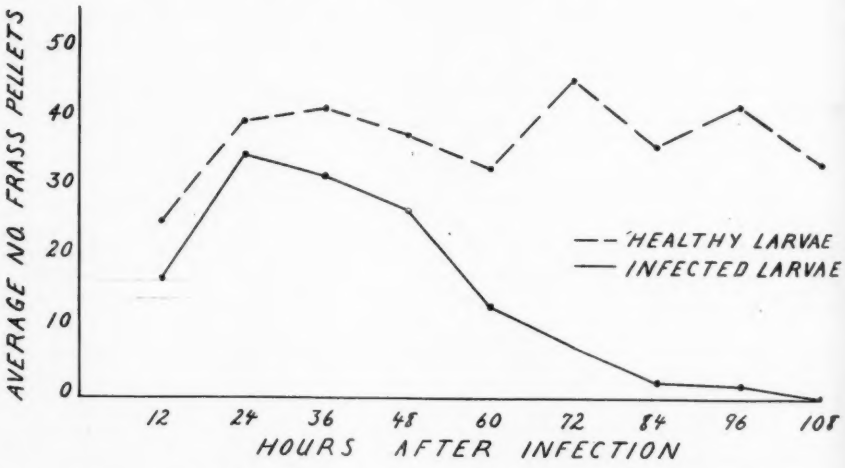

Fig. 2. The effect of the virus disease on frass drop of 40 European pine sawfly larvae.

Results

All European pine sawfly larvae fed foliage sprayed with a heavy suspension of polyhedra died from disease in four to ten days (mean 6.3 days) (Fig. 1), except those individuals which were approaching maturity and ready to spin cocoons. Studies, in progress, indicate that tissues of cocooned larvae are immune to the disease, as are the prepupal tissues of the European spruce sawfly, *Diprion hercyniae* (Htg.), to a similar polyhedral virus disease (6).

The median lethal dose was estimated to be from 100 to 500 polyhedra. An analysis of the mortality which occurred when larvae were fed 50, 500, and 5,000 polyhedra, showed that the larvae died in six to sixteen days (Fig. 1). The mean period to death was 9.8 days.

Polyhedral bodies were found only in the nuclei of the digestive cells of the mid-gut epithelium. In this respect also, the disease is similar to the polyhedral disease of the European spruce sawfly (4), and different from polyhedral virus diseases of the Lepidoptera. In the Lepidoptera, polyhedra are found chiefly in the nuclei of tracheal matrix, fat, hypodermal, and blood cells (9).

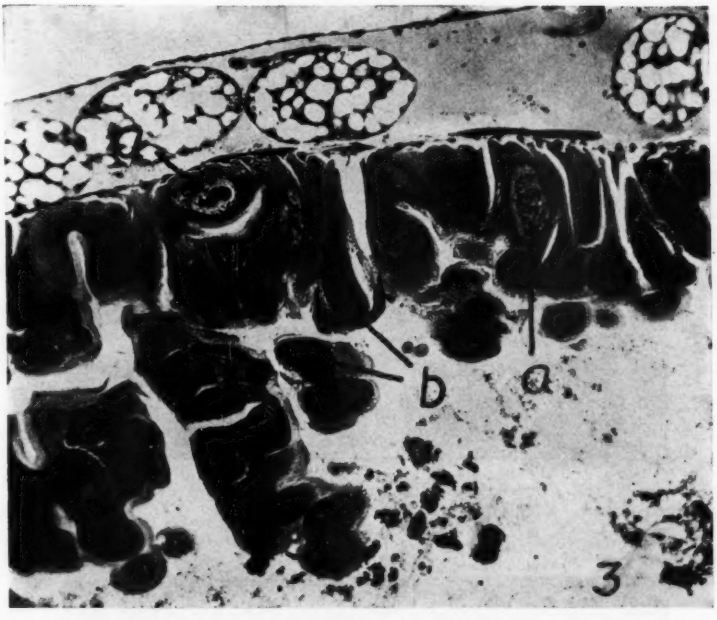

Fig. 3. Section of the mid-gut epithelium of a virus-infected European pine sawfly larva showing (a) nuclei in an early stage of infection in which nuclear material is coagulated and (b) polyhedra-filled nuclei. Fixed in Bouin's fluid and stained with Heidenhain's iron haematoxylin. x 300.

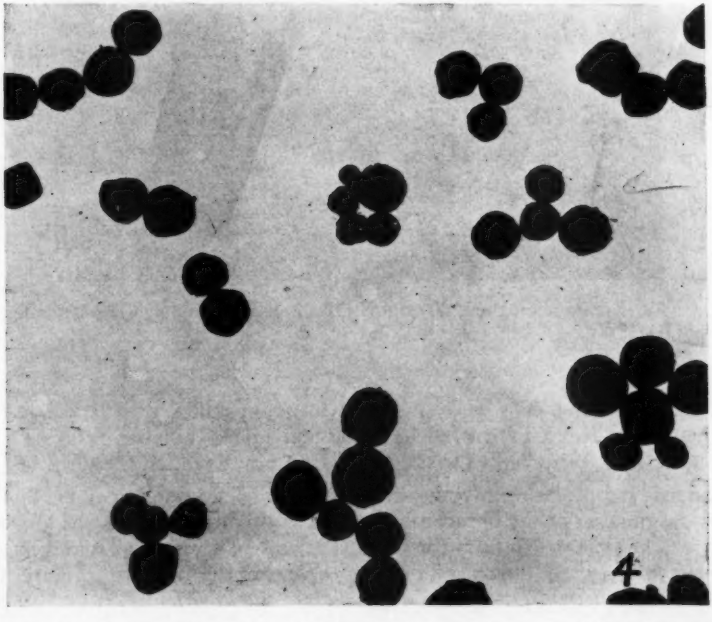

Fig. 4. An electron micrograph of polyhedra isolated from virus-killed European pine sawfly larvae. x 6,000.

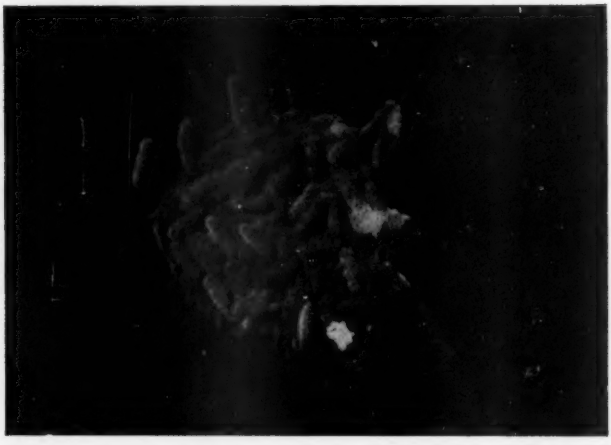

Fig. 5. An electron micrograph of a polyhedron partially dissolved in weak alkali showing virus particles. x 25,000.

Fig. 6. An electron micrograph of virus particles isolated from polyhedra of the European pine sawfly. x 25,000.

Infected digestive cells were found in European pine sawfly larvae 48 hours after they were fed the virus and a reduction in the number of frass pellets dropped by larvae occurred 48 to 60 hours after they were fed the virus (Fig. 2).

The first symptoms of infection are a swelling of the nucleus of the digestive cell and coagulation of the chromatic material of the nucleus. Polyhedra, which appear as small granules in both the chromatic and achromatic materials, increase in number and size and cause a further swelling of the nucleus. Figure 3 is a section through the mid-gut epithelium of a larva showing nuclei in various stages of infection.

The polyhedra average one micron in diameter and are frequently almost spherical (Fig. 4). They contain mostly rod-shaped particles about 250 x 50 millimicrons, and frequently also spherical particles. Bergold (2) has shown that rod-shaped and spherical particles are two stages in the development of polyhedral viruses. Figure 5 shows a partially dissolved polyhedron of the European pine sawfly containing mostly rod-shaped particles. Figure 6 shows (a) rod-shaped particles and (b) spherical particles isolated from polyhedra.

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The Use of a Virus Disease in the Biological Control of the European Pine Sawfly, *Neodiprion sertifer* (Geoffr.)[1]

By F. T. Bird

The European pine sawfly, *Neodiprion sertifer* (Geoffr.), is a serious defoliator of pine in many parts of Europe and Asia. Infestations of this insect have been controlled by weather, and frequently high percentages are destroyed by parasitic and predacious insects, by small mammals, and by birds. Infectious diseases are most frequently reported as having controlled outbreaks, namely: virus disease (4, 5), bacterial disease (12), fungus disease (8), bacterial and fungus diseases (7, 11), a disease not diagnosed (9).

The pine sawfly was discovered in 1925 in New Jersey where it attained outbreak proportions by 1938. By 1943 the northern half of New Jersey was infested, and infestations were found in Michigan and Ohio (6, 10). The insect was first reported in Canada at Windsor, Ontario, in 1939, and by 1949 had spread throughout most of southwestern Ontario. No evidence was observed by entomologists in Canada or the United States of a virus disease affecting populations of the sawfly, and intensive studies during the last three years, in southern Ontario, have shown the sawfly to be completely free from virus disease prior to its deliberate introduction.

In 1949, several virus-killed European pine sawfly larvae were obtained from Sweden. Laboratory studies (3) showed the virus (a polyhedral virus) to be

[1] Contribution No. 92, Division of Forest Biology, Science Service, Department of Agriculture, Ottawa, Canada.

extremely virulent against the Canadian population of *N. sertifer*, and it was propagated to provide material for field tests in 1950, 1951, and 1952.

This paper describes the methods used to disseminate the virus and the mortality from the disease which resulted. Epidemics of the disease during the years following its introduction, and the place of the virus in the natural control complex, will be discussed in a later paper. Preliminary reports on the dissemination of the virus have been published (1, 2).

Methods

Three methods were used to disseminate the virus. In 1950, a three-gallon pressure sprayer was used; in 1951, a mist-blower (Microsol model 304) was used; and in 1952, the virus was disseminated from an aircraft (Piper Cub) equipped with a boom-type sprayer.

Virus suspensions were prepared by macerating virus-killed larvae and allowing the material to rot in water at room temperature for several months. During this time many polyhedra settled out and formed a white layer in the sediment on the bottom of the container. The supernatant was discarded and the polyhedra were partially purified by repeated centrifugation and washing. Partial purification was necessary to obtain a reliable estimate of virus concentration.

Virus concentrations were determined by using a Petroff-Hausser counting chamber with dark-field illumination, to estimate the number of polyhedra per millilitre of water.

Diagnoses of larvae suspected of being infected with virus were made (1) by examining a drop of the body fluid, under the dark-field microscope, for polyhedra or (2) by examining, with the naked eye, the gut of a living larva. The gut of an infected insect is milky white and devoid of food. The gut of a healthy insect is translucent and filled with green plant material except when it is ready to moult or pupate when it is difficult to distinguish an infected larva from a healthy larva. In 1950 all the material was diagnosed under the dark-field microscope. In succeeding years, the microscope was used occasionally to check the visual diagnosis.

Dissemination of Virus with a Pressure Sprayer

In 1950, the virus was disseminated with a hand-operated three-gallon pressure sprayer. Virus suspensions containing 2,000, 20,000, 200,000, 2,000,000, and 5,200,000 polyhedra per millilitre of water were sprayed on foliage infested with the sawfly. The foliage was drenched with the virus suspensions; three gallons of each dilution were used to spray 20 trees about four feet in height. Relatively larger amounts were used to spray larger trees.

The virus was applied between May 25 and May 28. At intervals following spraying, colonies of larvae (approximately 60 larvae per colony) were examined on selected trees. The following categories were recorded: (1) all larvae in a colony living; (2) part of the larvae in a colony living and part dead; and (3) all larvae in a colony dead. Records were taken until June 9 when larvae began to drop from the foliage and spin cocoons.

On June 4 (7 to 10 days after spraying) virus-killed larvae were found on all trees sprayed with virus (Table I). At the lowest concentration of virus, 3.9 per cent of the colonies contained virus-killed larvae whereas at the highest concentration 91.6 per cent of the colonies contained virus-killed larvae. On June 7 (12 to 15 days after spraying) all larvae in some of the colonies were killed by virus: 11.9 per cent of the colonies were destroyed at the lowest concentration and 97.5 per cent at the highest virus concentration. Two days

TABLE I
THE EFFECT OF VARYING CONCENTRATIONS OF VIRUS DELIVERED FROM A PRESSURE SPRAYER ON RATES OF LARVAL MORTALITY

Date sprayed	Concentration of virus (polyhedra per millilitre of spray)	Number of trees examined	Number of colonies of larvae examined	CONDITION OF COLONIES (PERCENTAGE)					
				Colonies with some virus-killed larvae			Colonies with all larvae killed by virus		
				June 4	June 7	June 9	June 4	June 7	June 9
May 25	2,000	20	77	3.9	63.3	95.4	0	11.9	47.7
May 25	20,000	19	78	51.3	93.8	98.5	0	35.4	89.4
May 27	200,000	19	84	35.1	99.9	100	0	73.1	98.8
May 27	2,000,000	38	214	87.4	98.6	99.5	0	87.4	98.6
May 28	5,200,000	18	118	91.6	100	100	0	97.5	100

later these percentages increased to 47.7 and 100. No mortality from virus occurred in a control plot (350 colonies were examined on June 9 and June 14).

Dissemination of Virus with a Mist-Blower

A mist-blower (Microsol model 304) was placed at the windward edges of sawfly-infested pine plantations and, from a series of positions at each plantation, the virus was blown downwind into the plantations. Virus suspensions containing 10,000, 100,000, 1,000,000, 2,000,000, 4,000,000, and 20,000,000 polyhedra per millilitre of water were used. Figure 1 shows the distribution of mortality which resulted 11 days after spraying when 4,000 millilitres of a virus suspension containing 4,000,000 polyhedra per millilitre of water was blown into a sawfly-infested plantation. Figure 2 shows the distribution of mortality which resulted when equal volumes of two virus suspensions containing 100,000 and 1,000,000 polyhedra per millilitre were disseminated with the mist-blower.

The areas over which mortality occurred increased considerably with an increase in virus concentration up to 1,000,000 polyhedra per millilitre but less so when concentrations of virus greater than this were used. The best results were obtained when the virus was sprayed after sunset when the air was relatively calm. Under these conditions, two gallons of virus, containing 2,000,000 polyhedra per millilitre, caused heavy mortality after 18 days over an area of about five acres, and three gallons of virus containing 20,000,000 polyhedra per millilitre caused heavy mortality after 27 days over an area of about seven acres. In the latter test, virus-killed larvae were found about 900 feet from the point where the sprayer was placed.

Dissemination of Virus from an Aircraft

Virus was disseminated from a Piper Cub aircraft equipped with a boom-type sprayer. Three concentrations of virus were used containing 200,000, 1,000,000, and 5,000,000 polyhedra per millilitre of water. In the first experiment, the aircraft made six flights over a sawfly-infested pine plantation. The same virus concentration was used for each of two flights starting with the lowest concentration. The aircraft flew along parallel lines 300 feet apart and about 15 to 50 feet above tree top level. The virus was applied at the rate of about one-half gallon per acre. In a second experiment, in another plantation, the aircraft flew along parallel lines about 200 feet apart. A virus suspension con-

Fig. 1. Distribution of mortality from virus disease 11 days after 4,000 millilitres of a virus suspension, containing 4,000,000 polyhedra per millilitre of water, were sprayed with a mist-blower placed at one position (Station 7) at the edge of a sawfly-infested Scotch-pine plantation.

taining 5,000,000 polyhedra per millilitre of water was used and skim-milk powder was added at the rate of one pound to 20 gallons of water. Twenty-two gallons of the suspension were used to spray 50 acres.

Results obtained by spraying virus from aircraft, in the first experiment, were determined, 20 to 23 days after spraying, by estimating, for rows of trees at right angles to the line of flight: (1) the percentages of defoliation of the trees (Fig. 3); (2) percentages of colonies on the trees killed by virus (Fig. 4); and (3) percentages of colonies on the trees which contained some larvae killed by virus (Fig. 5).

Complementary graphs were obtained by plotting percentages of defoliation and percentages of colonies killed by virus. This is to be expected since most of

Fig. 2. Distribution of mortality from virus disease 13 days after 4,000 millilitres of two virus suspensions, containing 100,000 and 1,000,000 polyhedra per millilitre of water, were sprayed with a mist-blower placed at two positions (Stations 3 and 4 respectively) at the edge of a sawfly-infested Scotch-pine plantation.

Each circle represents a pine tree and the degree of insect mortality from disease corresponds to the degree to which a circle is inked in. An "X" in a circle indicates that the tree was not infested with the sawfly, a question mark that the tree was not examined, an "M" that an undetermined number of larvae were killed by the disease.

the colonies destroyed by virus died at an early stage of development before causing much defoliation. The plotting of percentages of colonies which contained some virus-killed larvae shows the area which received small amounts of virus and the areas secondarily infected.

By comparing the areas where 40 per cent or less defoliation occurred, it will be found that virus concentrations of 200,000, 1,000,000, and 5,000,000 polyhedra per millilitre of water produced swaths of about 80 feet, 110 feet, and

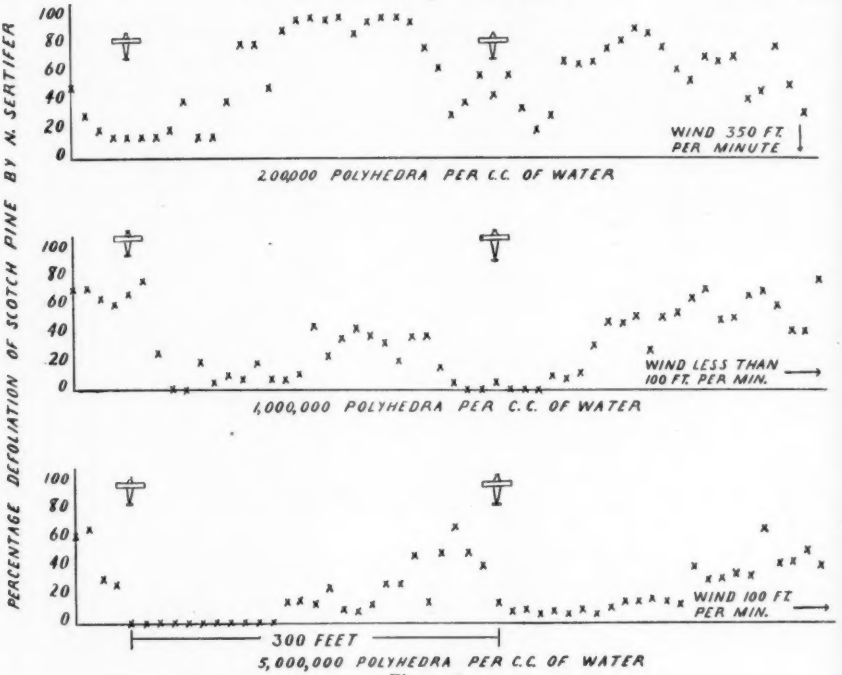

Figure 3

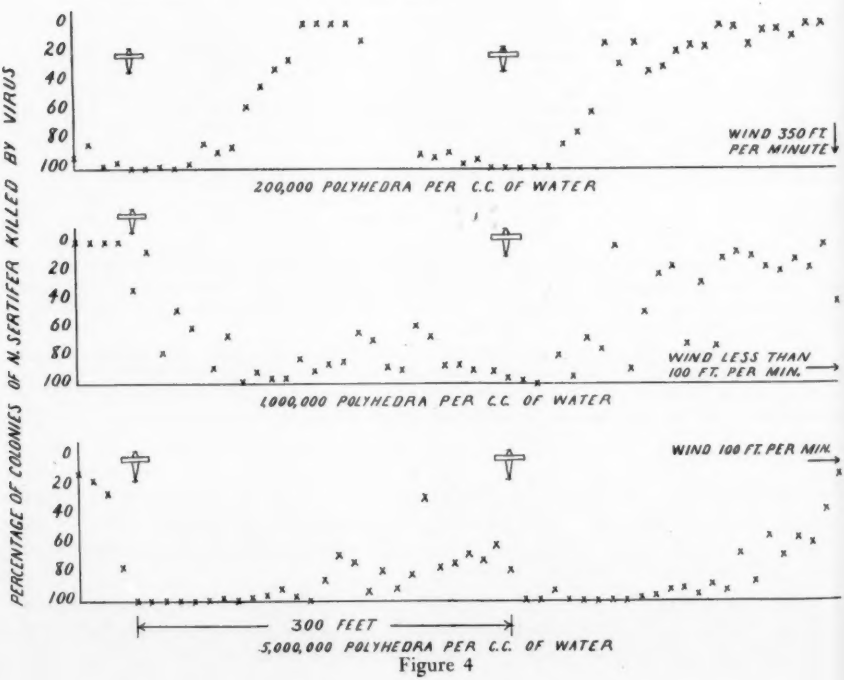

Figure 4

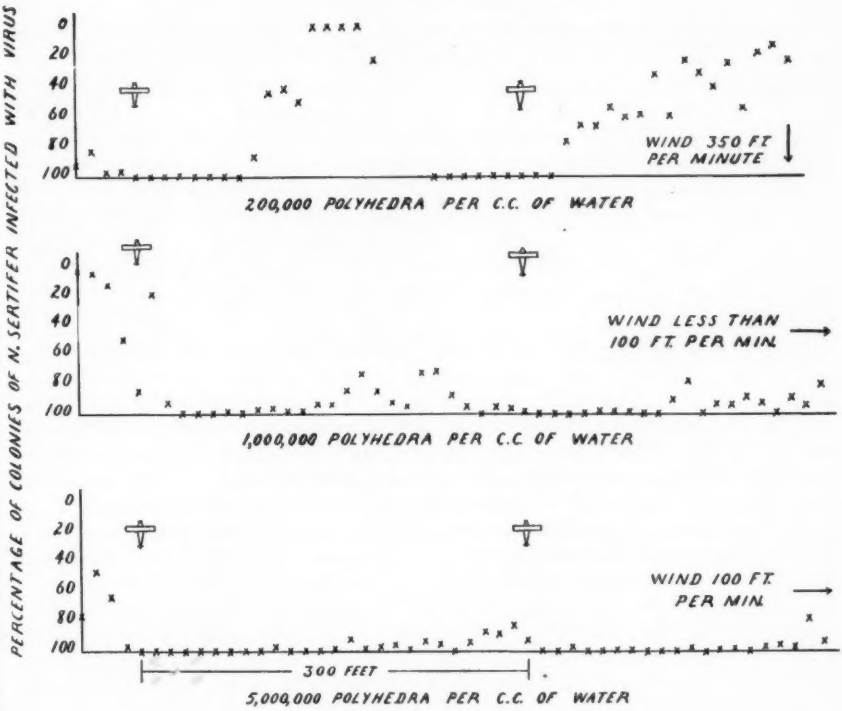

Figure 5

Figs. 3, 4, 5. Results obtained 20 to 23 days after virus suspensions were sprayed from an aircraft in one sawfly-infested Scotch-pine plantation. Fig. 3 shows results estimated by plotting tree defoliation. Fig. 4 shows results estimated by plotting percentages (percentage scale inverted) of colonies completely destroyed by virus. Fig. 5 shows results estimated by plotting percentages (percentage scale inverted) of colonies which contained some virus-killed larvae.

200 feet wide in which defoliation did not exceed 40 per cent in a plantation where defoliation would have been nearly 100 per cent. With the lowest virus concentration, the aircraft flew directly against a wind of 350 feet per minute which resulted in very little drift of the virus to the right or left. With the second and third virus concentrations, there was a slight breeze at right angles to the line of flight (less than 100 feet per minute and 100 feet per minute respectively). This resulted in considerable drift of the virus. During the first flight with the virus concentration of 1,000,000 polyhedra per millilitre of water, a tube connection on the spraying apparatus broke and the virus poured out in a solid stream on the right side of the aircraft and very little virus issued on the left side. The result of this is evident in Figures 3, 4, and 5.

The areas over which some mortality from virus occurred was much greater at the highest virus concentration and, under the conditions of this experiment, nearly all trees contained virus-killed larvae when the aircraft flew along parallel lines 300 feet apart. Some virus-killed larvae, not indicated in Fig. 5 were found at the end of the plantation about 600 feet from the line of flight.

TABLE II

MORTALITY CAUSED BY VIRUS DISEASE IN A PLOT 300′ x 100′ SELECTED AT RANDOM IN A SAWFLY-INFESTED PINE PLANTATION OF 50 ACRES SPRAYED WITH 22 GALLONS OF VIRUS SUSPENSION*

Date of spraying	Number of trees examined	Number of *N. sertifer* colonies examined	Condition of Colonies (Percentage)					
			On May 30			On June 6		
			Colonies with all larvae living	Colonies with some dead larvae	Colonies with all larvae dead	Colonies with all larvae living	Colonies with some dead larvae	Colonies with all larvae dead
May 16	850	1131	10.9%	64.4%	24.7%	0.8%	4.8%	94.4%

*Virus suspension contained 5,000,000 polyhedra per millilitre of water and skim-milk powder was added at the rate of 1 lb. per 20 gallons of water.

Table 2 shows the results of the second experiment in which 50 acres of heavily-infested Scotch pine were sprayed with 22 gallons of virus containing 5,000,000 polyhedra per millilitre of water to which skim-milk powder was added. Four plots 300 feet x 100 feet were selected at random in this plantation and colonies of European pine sawfly were examined on all trees in each plot. Table 2 shows the results obtained for one of these plots. The spray was applied on May 16 and the mortality was checked on May 30 and on June 6 when the first larvae dropped from the foliage and spun cocoons. By May 30, 24.7 per cent of the colonies were killed by virus and 64.4 per cent were infected and contained some virus-killed larvae. By June 6, 94.4 per cent of the colonies were completely destroyed, 4.8 per cent were infected and partially destroyed, and 0.8 per cent were apparently healthy.

Discussion

Mortality from the disease depends on the amount and concentration of virus used, the method of dissemination, and the stage of larval development at the time the virus is applied.

The rate at which larvae die from the disease depends, within limits, on the amount of virus consumed. Mortality was more rapid, and higher percentages of larvae were killed, in those areas where greater quantities of virus were deposited. When a mist-blower was used, the amounts of virus deposited varied with the distance from the spray source, the earliest mortality occurring near the spray source. The areas where infected larvae were found increased from day to day. Similarly, the swath of mortality caused by virus sprayed from aircraft increased in width from day to day. In the taller trees, it was observed that larvae died more rapidly at the top of the trees than did those feeding on foliage on the lower branches. With the same volume and concentration of virus, the addition of skim-milk powder to the water in which the virus was suspended produced an earlier mortality than when water alone was used. It is probable that the skim-milk powder acted as a sticker causing the droplets to adhere more firmly to the foliage.

Part of an insect population becomes infected by consuming virus sprayed on the foliage and part is secondarily infected by coming in contact with the former. It is impossible, except for the very early mortality, to distinguish one from the other. The virus may also be disseminated by other agencies, e.g., scavenging insects, predacious and parasitic insects, and birds, but these do not

appear to contribute very greatly to the enlargement of the area in which mortality occurs during the year virus is applied. That they do contribute to the total area infected was shown in one experiment by the spread of the disease from virus carefully smeared on the trunk of one tree in a formerly disease-free plantation.

The virus affects chiefly the feeding larval stages of the European pine sawfly although some mortality does occur after the larvae spin cocoons. Since, in the field, it takes about eight days from the time of spraying virus until mortality commences, very little mortality would result from spraying virus if the larvae were mature and ready to spin cocoons. To produce the greatest mortality, the virus should be applied at, or soon after, the time of hatching of the eggs. To prevent serious defoliation, the virus should be applied before the larvae have developed to the fourth instar.

This discussion has been concerned only with mortality produced by the dissemination of virus during the year of spraying. It is possible, by the use of a sufficiently heavy application of virus, to destroy a very high percentage of the feeding larvae in a sawfly-infested plantation during one year. By the judicious use of the virus, however, serious defoliation can be prevented by the destruction of part of a population, and the virus will be carried over from year to year in the surviving population while other control agencies, particularly parasitic insects, will continue to have sufficient numbers of their host for propagation. This phase of the study will be discussed in a later paper.

Summary

A virus disease of the European pine sawfly, *Neodiprion sertifer* (Geoffr.) was introduced into sawfly-infested Scotch-pine plantations in southern Ontario. The percentage and rate of mortality from the disease depended on the quantity of virus used, method of dissemination, and stage of larval development at the time of spraying. Over 90 per cent mortality resulted 14 days after virus suspensions, containing 200,000 or more polyhedra per millilitre of water, were sprayed with a three-gallon pressure sprayer. Heavy mortality from virus, over five and seven acres of sawfly-infested Scotch pine, resulted 18 and 27 days after two and three gallons of virus suspensions, containing 2,000,000 and 20,000,000 polyhedra per millilitre of water respectively, were sprayed with a mist-blower placed at two positions on the windward side of a plantation. Over 94 per cent mortality resulted 21 days after spraying when 22 gallons of virus, containing 5,000,000 polyhedra per millilitre and in which skim-milk powder was added as a sticker, were sprayed from an aircraft over 50 acres of sawfly-infested Scotch pine. Series of tests are described in which the aircraft flew along parallel lines 300 feet apart using virus suspensions containing 200,000, 1,000,000, and 5,000,000 polyhedra per millilitre of water.

Acknowledgments

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Effects of the Destruction of the Current Year's Foliage of Balsam Fir on the Fecundity and Habits of Flight of the Spruce Budworm[1]

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Introduction

When spruce budworm larvae emerge in the spring, they either mine the needles of old foliage or feed upon the freshly opened staminate flowers of balsam fir. As soon as the vegetative buds begin to expand, the larvae abandon the needle mines for this newer and more succulent growth. Later, when the pollen is shed, the staminate flowers are in turn abandoned in favour of new shoots. Usually, the larvae continue to feed on the new shoots until pupation. When this insect reaches epidemic proportions, however, the current year's growth is often totally destroyed prior to the completion of the larval stage. Late spring frosts have also been known to destroy, in part, or even completely, the shoots of the current year's growth. Under these conditions spruce budworm larvae must resort to feeding on old foliage.

Laboratory experiments carried out in 1949 indicated that adults from fifth- and sixth-instar spruce budworm larvae reared on old foliage produced fewer eggs than insects reared on the current year's growth for the same period of time (Blais 1952). Field studies were undertaken in 1950, 1951, and 1952 to determine if the destruction of new foliage on balsam fir affected the fecundity of this insect.

Methods

Pupae were collected from two plots in the region of Cedar Lake in northwestern Ontario. Both plots were established in overmature coniferous stands where balsam fir was a predominant species. In Plot A the spruce budworm

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reached epidemic proportions in 1945, and in Plot B, two years later. In 1951 and 1952, the infestation was on the decline in Plot A while it was maintaining itself in Plot B. Material was collected by obtaining balsam-fir branches from each of the plots at the time when most of the insects were in the pupal stage. The degree of defoliation of the branches was calculated according to a system developed by Fettes (1947). Pupae were collected from the branches and placed in 1′ x 1′ x 2′ screen cages, the pupae from each plot being kept in separate cages. At the time of adult emergence, the cages were examined for pairs in *copula;* these were caught and kept in vials until they separated. The fertilized females were then placed on balsam-fir tips in individual lantern globes. All of the eggs deposited on the foliage by each female were counted. In 1952, in addition to collecting pupae from the larger trees in Plot B, material was obtained from a near-by open-grown thicket of balsam-fir reproduction, where the trees measured about 15 feet in height, and this material was treated separately.

Results and Discussion

Table I gives the degree of defoliation of balsam fir, and the mean number of eggs produced per female budworm moth from plots A and B for the years 1950, 1951, and 1952. In 1950, the defoliation of the current year's growth in Plot A was 100 per cent, while in Plot B it was between 81 and 90 per cent, and significantly more eggs were produced by the moths from Plot B than by those from Plot A. In the following two years, the reverse took place; the current year's growth was completely destroyed in Plot B but not completely destroyed in Plot A, and the moths from Plot A produced significantly more eggs than those from Plot B in both years. The current year's growth on the balsam-fir reproduction near Plot B was not completely destroyed in 1952, and the insects obtained from these trees produced significantly more eggs than those from the taller trees in Plot B. There is no significant difference from year to year in the number of eggs produced by insects from trees where the current year's growth was entirely destroyed prior to the completion of the larval stage (Plot A, 1950; Plot B, 1951, 1952), nor is there any difference in

TABLE I
THE DEGREE OF DEFOLIATION OF BALSAM FIR, AND THE AVERAGE NUMBER OF EGGS PRODUCES BY SPRUCE BUDWORM MOTHS FROM PLOTS A AND B FOR VARIOUS YEARS

Plot	Year	Degree of defoliation of current year's growth	No. of Adults	Mean No. of Eggs
A	1950	100	27	96 ± 11
B		81 – 90	27	157 ± 12
A	1951	91 – 100	24	169 ± 10
B		100	25	109 ± 9
A	1952	71 – 80	32	162 ± 9
B		100	32	127 ± 7
B (reproduction)		81 – 90	32	182 ± 8

the number of eggs produced by insects from trees where the defoliation was not complete (Plot B, 1950; Plot A, 1951, 1952; Plot B (reproduction), 1952).

The present studies indicate that when spruce budworm populations reach the point where all the current year's growth is destroyed prior to the completion of the larval stage, the number of eggs per surviving female adult decreases, and that fecundity increases again as populations decline to the point where defoliation of the current year's growth is not complete.

Wellington and Henson (1947) mention that fully gravid females of the spruce budworm cannot fly until after some oviposition has occurred. However, this does not apply at times of high populations, when many insects fail to reach full size for lack of proper food. It has been shown that the weight of pupae from spruce budworm larvae collected in the fourth, fifth, and sixth instars and fed on old foliage was significantly less than the weight of pupae from larvae collected in the field at the same time but reared on the current year's foliage (Blais, 1952). Gravid female moths from insects reared on old foliage or from insects collected in the field in areas of severe defoliation, were able to fly in an upward direction soon after emergence.

Many reports have been made of mass flights of the spruce budworm in areas adjoining, and even some distance away from, heavily infested forests (Johannsen, 1913; Tothill, 1923; Daviault, 1949; Greenbank, 1950). It is possible that these mass flights consisted of undersized adults transported in a manner similar to that postulated by Henson (1951) for partially spent females, since females from heavily defoliated areas can take flight shortly after emergence.

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Toxicité pour la Blatte américaine d'un nouvel analogue du DDT: 1,1,1-trichloro-2,2-bis-(p-cyanophényl)-éthane[1]

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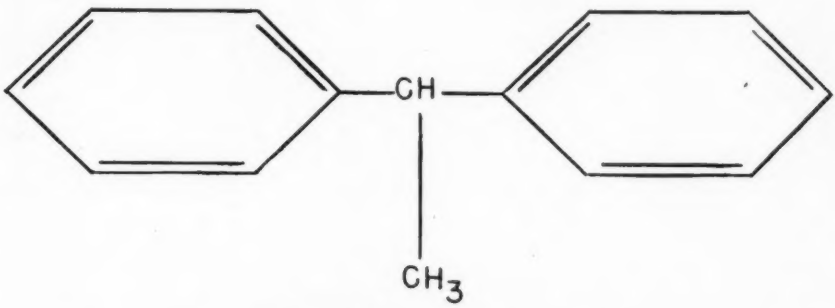
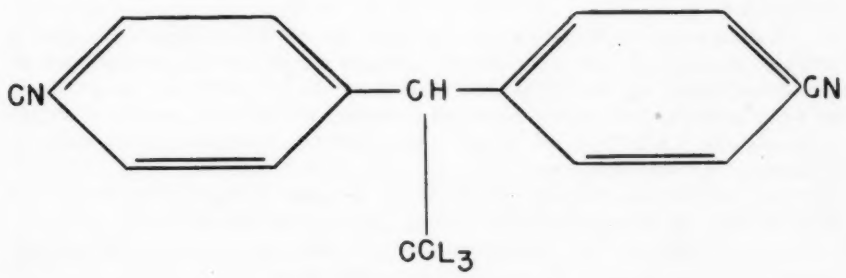
Depuis la découverte du pouvoir insecticide du DDT, des recherches intensives ont été faites sur d'autres composés synthétisés à partir de la charpente squelettique du DDT, à savoir le 1,1-diphényléthane:



De ces composés analogues au DDT, certains montrent une valeur insecticide supérieure à celle du DDT; d'autres s'avèrent inférieurs, du moins dans les conditions expérimentales que nous avons choisies. Nous présentons ici les résultats que nous avons obtenus dans nos expériences sur la toxicologie du dérivé cyanuré du DDT. Ce composé a été synthétisé pour la première fois par Perron (4,5) à l'Institut de Chimie de l'Université de Montréal. Nous avons utilisé la méthode mise au point par cet auteur pour préparer les quantités dont nous avions besoin pour notre travail. Le dérivé cyanuré, le 1,1,1-trichloro-2,2-bis-(p-cyanophényl)-éthane, possède la structure chimique suivante:



Méthode expérimentale

Pour l'évaluation de la toxicité de ce nouveau composé, nous avons choisi, comme matériel biologique, la blatte américaine, *Periplaneta americana* (L.). Les composés soumis à l'essai furent injectés dans l'hémocoele de l'insecte au moyen d'un appareil que nous avons monté selon les données de Heal et Menusan (2).

L' appareil à injection est essentiellement constitué d'une micro-pipette jaugée

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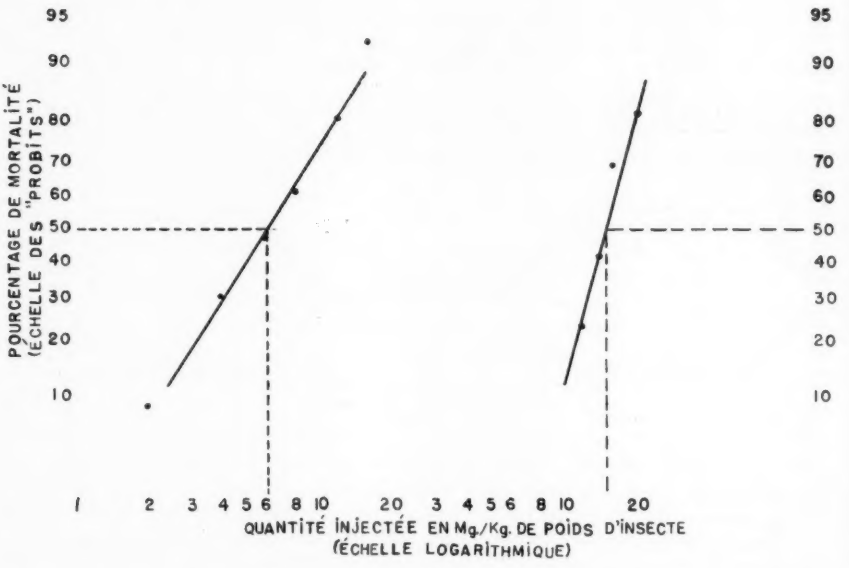
[3]Assistant en recherche.

GRAPHIQUE I- Toxicité du 1,1,1-trichloro-2,2-bis-(p-chlorophényl)-éthane chez Periplaneta americana(L.).



en 0.001 de ml. et pouvant contenir 0.2 ml. Une aiguille hypodermique no 27 est assujettie à l'extrémité effilée de la pipette. L'autre extrémité de la pipette est reliée à un cylindre rempli de mercure. Une vis micrométrique plongeant dans le mercure permet, par son déplacement, d'opérer une pression graduelle et lente sur la substance à injecter que contient la micro-pipette. La pipette et son dispositif de contrôle sont attachés à un support vertical, de sorte que les mains de l'opérateur demeurent libres pour tenir l'insecte et pour manipuler la vis micrométrique.

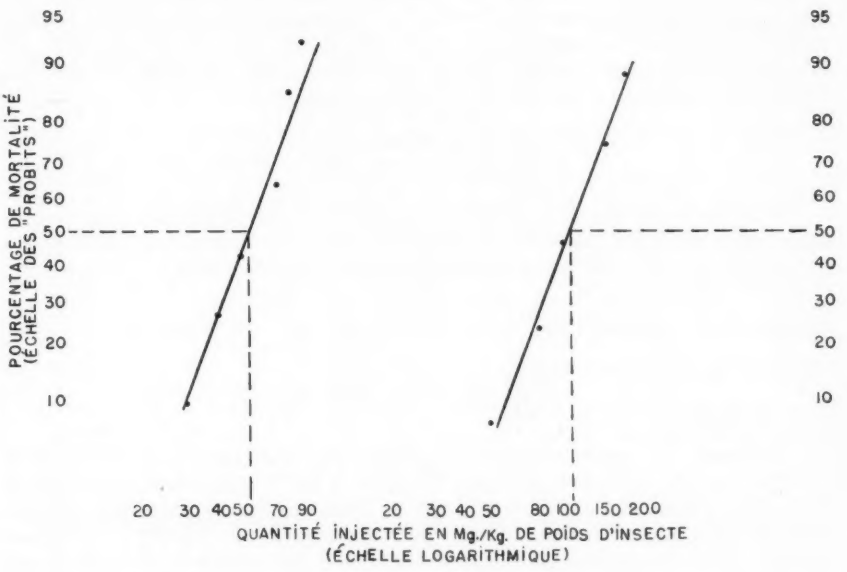
Nous n'avons utilisé dans ces expériences que des adultes âgés d'au moins 5 jours et ne dépassant pas 2 semaines. L'insecte est préalablement anesthésié au gaz carbonique. Les injections sont faites à travers la conjonctive du 3e ou du 4e segment abdominal, en un point latéro-ventral, entre le stigmate et la suture tergo-pleurale. L'aiguille est dirigée antérieurement et maintenue parallèle au tégument. La micro-pipette étant fixe, c'est l'insecte qui est manié. On fait pénétrer l'aiguille sur une longueur d'environ 3 à 5 mm. puis on injecte un volume total de 0.03 ml. d'une suspension aqueuse du composé chimique.

Après l'injection, les insectes sont placés dans des jarres individuelles et pourvus de nourriture et d'eau. Ces jarres sont conservées pendant six jours à la température du laboratoire pour l'observation quotidienne de la mortalité.

Résultats

Des essais que nous avons faits avec le véhicule seul (phases dissolvante, émulsifiante et dispersante) nous ont permis d'établir la faible toxicité de celui-ci pour *Periplaneta americana*. En effet, le pourcentage de survie au bout de six jours est de 93.3% chez les mâles et de 95.6% chez les femelles. Ces valeurs ont été utilisées pour obtenir nos pourcentages corrigés de mortalité (1). Afin de pouvoir établir un point de comparaison entre nos nouveaux composés et un

GRAPHIQUE 2-Toxicité du 1,1,1-trichloro-2,2-bis-(p-cyanophényl)-éthane chez Periplaneta americana(L.)



composé dont la valeur insecticide est connue [indice de toxicité (6)], et aussi afin d'éprouver l'exactitude de notre méthode, nous avons d'abord fait une série d'injections avec le DDT.

Nos résultats avec le DDT sont illustrés dans la figure no 1. Les pourcentages de mortalité sont placés en ordonnées suivant l'échelle des "probits". Les quantités injectées en mg./kg. de poids d'insecte, sont disposées en abscisses d'après l'échelle logarithmique. Les points sur le graphique représentent les pourcentages corrigés de mortalité que nous avons obtenus à chaque concentration correspondante. Chaque point est le résultat d'une moyenne de trois essais successifs faits sur quinze individus chacun. Le graphique de gauche donne la dose léthale médiane du DDT pour les mâles, soit 6.2 mg./kg. de poids d'insecte; celui de droite représente la dose léthale médiane du même composé pour les femelles, soit 15 mg./kg.

Menusan (3), qui a travaillé dans des conditions assez analogues aux nôtres, a trouvé une dose léthale médiane, pour la blatte américaine adulte, de 8 mg./kg. pour les mâles et de 20 mg./kg. pour les femelles. Tobias, Kollross et Savit (7) donnent une dose léthale médiane, pour le DDT injecté sous forme d'émulsion chez une population mixte de blattes américaines, de 18 mg./kg. Nos valeurs correspondent assez bien à celles des auteurs précités pour nous rassurer sur la validité de notre technique.

Nous avons appliqué les mêmes méthodes expérimentales dans nos essais avec le dérivé cyanuré. Nos résultats sont résumés dans la figure no 2. La dose léthale médiane de ce composé est de 54 mg./kg. pour les mâles et de 108 mg./kg. pour les femelles.

Afin de comparer la valeur insecticide de ce nouveau composé avec celle d'un autre composé connu, nous avons déterminé son indice de toxicité (I.T.).

L'expression "indice de toxicité" a été définie par Yun-Pei Sun (6) comme étant le rapport entre la dose léthale médiane (LD 50) de l'insecticide choisi comme standard et celle de l'insecticide essayé dans les mêmes conditions, multiplié par 100. Cette façon d'exprimer la toxicité des insecticides élimine presque entièrement les effets de certains facteurs de variation tels que: la susceptibilité des insectes; le milieu ainsi que les légères variations dans les méthodes d'essais (6). L'indice de toxicité est calculé de la façon suivante:

$$\text{I.T.} = \frac{\text{LD 50 du standard}}{\text{LD 50 de l'échantillon}} \times 100$$

L'indice de toxicité de l'insecticide standard est toujours considéré égal à 100. En employant les doses léthales médianes trouvées pour le dérivé cyanuré, et en considérant le DDT comme insecticide standard, nous obtenons:

$$\text{I.T. du dérivé cyanuré} = \frac{6.2}{54} \times 100 = 11.48 \text{ pour les mâles.}$$

$$= \frac{15}{108} \times 100 = 13.89 \text{ pour les femelles.}$$

Menusan (3), par la méthode d'injection dans l'hoemocœle, a déterminé la toxicité d'un certain nombre d'insecticides, dont le DDT, pour la blatte américaine. Nous avons calculé l'indice de toxicité de quelques-uns de ces composés afin d'établir leur toxicité relative, toujours par comparaison avec le DDT. Ceci nous a permis d'établir l'activité biologique relative du dérivé cyanuré avec celle de ces autres composés et nous avons obtenu les valeurs suivantes:

1° *pour les mâles*:
Pyréthrines (I et II) > Derris[1] > DDT > Dérivé cyanuré > Nicotine[2] > Fluorure de Sodium > Léthane 384[3].

2° *pour les femelles*:
Pyréthrines (I et II) = Derris > DDT > Nicotine > Fluorure de sodium > Dérivé cyanuré > Léthane 384.

Remerciements

Ce travail a été rendu possible grâce à un généreux octroi fourni par le Conseil des Recherches Agricoles du Ministère de l'Agriculture de la province de Québec.

Summary

The median lethal dose of DDT for *Periplaneta americana* (L.), has been established as follows: for the males, 6.2 mg./kg.; for the females, 15 mg./kg.

Identical tests with a new DDT analog: 1,1,1-trichloro-2,2-bis-(p-cyanophenyl)-ethane, have been conducted on the same insect. The median lethal dose is 54 mg./kg. for the males and 108 mg./kg. for the females.

These values have been determined by the blood stream injection method described by Heal and Menusan.

In comparing the toxicity index of this cyanide analog with that of other compounds given in the literature for the same insect, it has been possible to establish the following relations:

1Concentration en roténone. (E.T. 4 x roténone).
2A'caloïde libre.
350% de B-butoxy B' thiocyanodiéthyl éther.

1° *for the males*:
Pyrethrins (I and II) > Derris > DDT > Cyanide analog > Nicotine > Sodium fluoride > Lethane 384.

2° *for the females*:
Pyrethrins (I and II) = Derris > DDT > Nicotine > Sodium fluoride > Cyanide analog > Lethane 384.

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Revision of the Occiduaria-argillacearia Complex of the Genus Itame, with Descriptions of New Races (Lepidoptera, Geometridae)

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That section of the genus *Itame* to which have been assigned the names *argillacearia* and *occiduaria* of Packard, *modestaria* and *olivalis* of Hulst and *andersoni* Swett has provoked many a sigh of exasperation among collectors and systematists trying to organize their material. The present paper represents several years of intermittent study and observation, and although no drastic changes in nomenclature or arrangement seem warranted, I shall set forth my conclusions for what they are worth. This may actually be regarded as a supplement to Dr. J. McDunnough's remarks on the group in a paper of 1924 (Notes on the *Ribearia* Group of the Genus *Itame*. *Can. Ent.*, Vol. 56, p. 271), additional material having been examined that was not available to him at that time.

Male Genitalia

An exhaustive study of the genitalia failed to reveal any reliable genitalic differences among the three most confusing populations involved—*occiduaria*, *andersoni* and *argillacearia*. The differences in male genitalia mentioned by Dr. Forbes (Lepidoptera of N.Y. and Neighbouring States, Pt. II, p. 38) in describing how to differentiate between *occiduaria* and *argillacearia* apply, but only in a very broad sense.

In my experience, *occiduaria*, and even more so the eastern race of *andersoni*, are inclined to have a somewhat narrower and more pointed lower lobe than *argillacearia*, in extreme cases attaining a shape rarely seen in the last species, but if one makes sufficient slides all stages of roundedness or pointedness may sooner or later be found in any one species. The differences in length of the free end

of the costa in proportion to the part that adjoins the rest of the valva constitute the most reliable genitalic character, since this free end is usually a little longer in *andersoni* and *occiduaria* than in *argillacearia*. In *andersoni* the free end of the costa commonly protrudes at least twice as far as what may be called the free tip of the lower lobe (i.e., the triangular portion that juts outward beyond the two flanges). In *argillacearia* the free end of the costa is less than twice as long and, as mentioned by Forbes, has a tendency to be stouter. But this is very inconsistent. These remarks do not apply as well to *occiduaria* as to *andersoni*, since the former is more inclined to be quite inseparable from *argillacearia* genitalically. I found the two flanges on the valva to be of no help, since all extremes of variation seemed to occur in each of the species.

There appears to be a minor difference in the form of the tegumen. Usually just below the posterior end of the oedeagus as mounted on the slide (but actually dorsad to it), the inner margins of the two sides of the tegumen meet forming an inverted V. The apex of this V is often quite sharp in *argillacearia*, and nearly always more rounded in both the eastern and western races of *andersoni*. In *occiduaria* it is most commonly either intermediate, or much as in *argillacearia*. This difference in the tegumen is too inconsistent to be used alone as a distinguishing feature, but in some cases it can help to shed light on the identity of a specimen when used in conjunction with the other points of difference, dubious though they all are.

I am figuring the male genitalia of *argillacearia* and the eastern race of *andersoni* only, since the other species were adequately treated in this respect by McDunnough. His genitalic figure of *argillacearia* probably represents an eastern example of *andersoni*, although it is from one of those unusually immaculate Mer Bleue specimens on which I comment later.

Female Genitalia

The only conspicuous feature of female genitalia in *Itame* is a heavily chitinized, stellate signum on the ventral side of the thin, membranous bursa copulatrix. Figures 3 and 4 illustrate how the signum may vary in any one of the species. As a character for separating the most closely allied species in the group under discussion it is quite useless. *Sulphurea* however has a larger and more elaborate signum. The ductus bursae in *andersoni* is shorter than in *argillacearia* or *occiduaria*, but otherwise there are no tangible differences.

Itame occiduaria Packard

Caulostoma occiduaria Pack., Sixth Rep. Peab. Acad. Sc., 52, 1874.

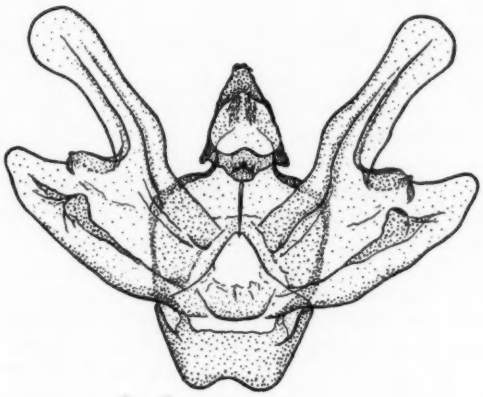
Male. Ground color of the primaries varies from intense yellow to very pale ochreous or cream color, variably dusted with brown scales, some examples being entirely free from this granular scaling. Four irregular cocoa-brown markings on the costa, sometimes only two or three. Discal spot, when present, of the same color, either free or united with the second costal marking. The course of the postmedial line may be narrowly outlined by brown scaling, but more commonly it expands outwardly into a broad, cocoa-brown shade for one-half to two-thirds of its length from the inner margin. This shade is of variable intensity, and sometimes is broken into two spots or patches. Fringes concolorous with the ground color except for a brown crescent just below the apex in all specimens examined, imparting a slightly falcate appearance to the primaries.

Secondaries only slightly paler, often with a narrow brown continuation of the postmedial line running through the middle, and sometimes traces of other

lines. Discal spot inconspicuous or absent. Fringes may be partly checkered with brown. 25-31 mm.

Female. Similar to the male but much smaller. 20-24 mm.

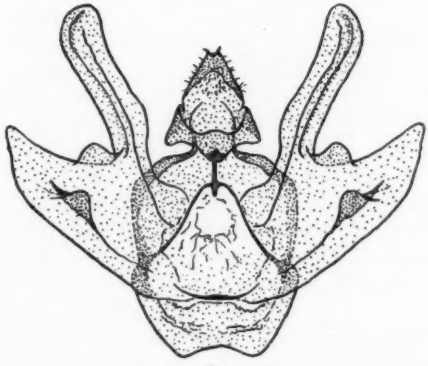
Geographical Variation. The shade of the ground color does not seem to have a great deal to do with locality, since before me are both bright yellow and cream colored examples from southern Manitoba, Saskatchewan, the vicinity of Calgary, Alta. and from Colorado. Some specimens from Calgary are unusually pale and colorless, coming closer to *andersoni* than any other *occiduaria* I have seen. They retain, however, the large size and full complement of brown markings characteristic of *occiduaria*. A series of six males from Grand Bend, Ont. (S.



1

1a

3



2

2a

4

1. *Itame argillacearia* Pack., Horseheads, N.Y. Male genitalia.

1a. Oedeagus of the specimen shown in Fig. 1.

2. *Itame andersoni orientis*, new race, Glenville, Cumberland Co., N.S. Male genitalia.

2a. Oedeagus of the specimen shown in Fig. 2.

3. *Itame occiduaria* Pack., Aweme, Man. Signum on the bursa copulatrix of the female genitalia.

4. *Itame occiduaria* Pack., Riding Mt. Park, Man. Signum on the bursa copulatrix of the female genitalia. Figs. 3 and 4 illustrate the amount of variation found in the signa of individuals within the same species.

of Goderich on Lake Huron) are all especially well marked and more heavily dusted with dark scales than is usual in western material.

Type locality: The types, two males, came from Oregon and Colorado.

Range: In hilly or wooded localities from southern B.C. eastward through, and just north of, the prairie regions (Cypress Hills, Waskesiu Lake, Riding Mt. Park) to the shores of Lake Huron in south Ontario. In the U.S. it follows the mountains southward through Washington, Oregon, Idaho and Montana to Denver and Salida, Colo., and ranges eastward through South Dakota, Nebraska to Lake Katherine, Oneida Co., Wis. It is also reported from Ithaca, N.Y., where it is apparently very rare.

Flight Period: June 11-August 13.

Early Stages: Larva on *Arcteostaphylos* (Criddle), *Ribes* and *Amelanchier* (McDunnough).

Material examined: 36 specimens.

Itame andersoni Swett

Diastictis andersoni Swett, *Can. Ent.*, Vol. 48, p. 251. 1916.

Male. The reader had best be referred to Swett's reasonably thorough description of the type male. The original description however, makes no mention of the amount of variability to be expected. The closest thing to topotypical material available for study are two males from near Whitehorse, Yukon, and these fit the original description well, except for only very minor details. Typical *andersoni* is mouse gray, much like *argillacearia*, but always with 2 to 4 brown costal spots, and brown scaling of varying extent along the course of the t.p. line, in some specimens expanding to a broad shade in the lower half near the inner margin, as in *occiduaria*. There is also a line through the middle of the hind wing and faint discal spots on both wings may be present. T.a and medial lines, present in the type, rarely distinct. Any of the markings, except the costal spots, may be obscure or absent, but none of the specimens before me are as immaculate as *argillacearia*. Contrary to Swett's opinion, the curvature of the lines does not constitute a reliable difference between this species and *occiduaria*, some *andersoni* having an almost straight t.p. line. The dark section of fringe below the apex is distinct only in paler specimens. 22-28 mm.

Female. Only four females of *andersoni* are available for study, three from Cameron Bay, Great Bear Lake and one from Eastmain River, Que. They have much reduced wings and probably do not fly much. Coloring pale ochreous, or brownish-ochreous, heavily dusted with dark brown scales. Lines and costal spots as in the male but of a lighter brown. Dark section of fringe below apex usually distinct. The rest of the fringes may be partly checkered with brown. 19-22 mm.

Geographical Variation. Specimens from Dawson, Y.T. tend towards a more luteous ground color, dusted with dark scales. These taken by Dr. McDunnough at Nordegg, Alta. are normally colored but all have broader wings (measured on a straight line through the anal angle meeting the costa at 90°). Specimens from Cameron Bay, Great Bear Lake and from Rupert House, Que. are normal *andersoni*. Churchill, Man. specimens are very heavily marked, but those from Pikwitonei, also in N. Manitoba, are indistinctly marked. Examples from Knob Lake, Que. are normal in form and maculation but small.

Type locality: Atlin, B.C.

Range: Atlin and Dawson eastward and southward through the Northwest Territories, northern Alberta, northern Manitoba to Northern Quebec.

Flight Period: July 6-August 11.
Early stages: Unknown, but possibly also on *Vaccinium* like the S.E. race.
Material Examined: 31 specimens.

***Itame andersoni orientis* new race**

Male. Ground color of the primaries very pale gray to pale cream, tending to be more ochreous than typical *andersoni*; uniformly sprinkled with brown scales. Four small but distinct brown spots on the costa, the second one from the apex marking the point where the t.p. line meets the costa. This line is weak and interrupted, and beyond it there is a suggestion of a submarginal line which would, were it continuous, meet the costa at the spot nearest the apex. Outwardly, in the curve near the inner margin, the t.p. line expands into a brown shade. In the holotype this is not very distinct, but in some specimens it becomes a conspicuous patch of brown scaling occupying the space between the t.p. line and the position of the submarginal line, as in some *andersoni* and nearly all *occiduaria*. Hind wings of the same colour, with a weak continuation of the t.p. line through the middle. Discal spots on both wings indistinct or absent. Fringes essentially concolorous with the ground, except for the usual brown section near the apex of the primaries. 22-26 mm. Holotype 24 mm.

Female. Wings reduced as in typical *andersoni*. Coloring as in the male but paler and more ochreous. A heavier sprinkling of darker scales give it a more granulate appearance. Ground a little yellower than in the female of *andersoni*. Markings as in the male but commonly of a lighter shade of brown. Brown shade in the lower curve of the t.p. line absent in the allotype, conspicuous in only one of the seven females. Fringes like the male but more inclined to be checkered with brown, as in the allotype. 18-21 mm. Allotype 20 mm.

Holotype– ♂, Auburn, Kings Co., N.S. June 30, 1951.

Allotype– ♀, Coldbrook, Kings Co., N.S. Bred June 26, 1951 from a larva on *Vaccinium*.

Paratypes–29 ♂ ♂, Auburn, Kings Co., N.S. June 30, 1951.

Holo- and allotype deposited in the Canadian National Collection. Paratypes in the C.N.C., Nova Scotia Museum of Science, American Museum of Natural History, and the collections of Mr. John L. Sperry, Mr. J. G. Franclemont and Mr. L. R. Rupert.

Range: Southern Manitoba (Brandon, where it apparently flies in company with normal, bright yellow *occiduaria*), Southern Ontario, with the possible exception of the Niagara Peninsula, southern Quebec, N.B., P.E.I. and N.S., including Cape Breton Is.

Flight Period: June 16-Aug. 7.

Early Stages: The only life history note available is a brief description of the larva from which the allotype was bred. Larva rather short and chunky, black with a pink dorsal stripe. Broader orange-pink lateral stripe with a patch of white bearing three small black dots on each segment. Black dorso-lateral area divided down the middle by a very fine pinkish-white stripe and also broken by a few obscure mottlings of the same color. Ventral area dirty pink with small black dots. Thoracic legs blackish laterally. Head black with horizontal bar of pinkish-white on sides joining in front. Skin tuberculate and hairy. On *Vaccinium* in May. A series of adults bred from *Vaccinium* in the Ottawa region was also examined.

Material Examined: 110 adults, 1 larva.

Remarks: This is not too well defined a race but since *andersoni* occupies such an enormous territory, from Atlin, B.C. to the Annapolis Valley of N.S., it seemed natural to look for points of racial distinction. A segregation of north-western and south-eastern specimens for comparative study showed certain differences of size, coloring, and maculation and it was actually possible to draw a rough line between the distributions of the northern and southern populations. In the west the more southern population seems to be replaced by *occiduaria*, which it meets in southern Manitoba. The differences between *andersoni* and *orientis* can only be properly studied with extensive series of specimens, since some individuals of either population could readily be lost in a series of the other, were it not for their locality labels.

Orientis is extremely variable, ranging all the way from gray, immaculate individuals to pale yellowish, well marked specimens suggestive of *occiduaria*. Such extremes, however, are relatively rare. A curiously immaculate form, in coloring and maculation quite inseparable from *argillacearia*, occurs at the Mer Bleue, near Ottawa, and I place it here rather doubtfully on the basis of male genitalia, which seem to be those of *orientis*.

All four caught females of *orientis* differ from the three bred ones in having the markings more diffuse and indistinct. A bred female was selected as the allotype only because of its locality—only a few miles from that of the holotype; otherwise one of the captured N.B. females would have been selected.

Itame argillacearia Packard

Tephrina argillacearia Pack., Sixth Rep. Peab. Acad. Sc., p. 48, 1874.
Diastictis modestaria Hlst., Ent. News, VI, 11, 1895.
Diastictis olivalis Hlst., Can. Ent., XXX, 164, 1898.

Male. Smooth, uniform gray, immaculate except for one or two darker gray costal markings on most specimens, the outer one presumably marking the junction of the t.p. line with the costa. Occasional specimens show a trace of a dark shade along the course of the t.p. line. Wings sometimes faintly mottled with ochreous, especially near the costa and on the secondaries. One specimen from Passadumkeag, Me. and another from Trenton, Ont. would best be described as pale ochreous heavily dusted with gray scales. Fringes concolorous with the wings and of a satiny lustre. 23-29 mm.

Female. Pale ochreous, heavily mottled or dusted with gray, giving a ground effect similar to *evagaria* Hlst. but darker. Markings, when present, as in the male. Fringes concolorous with the ochreous ground color, at least partially checkered with gray. 23-25 mm.

Type Locality: Brunswick, Me.

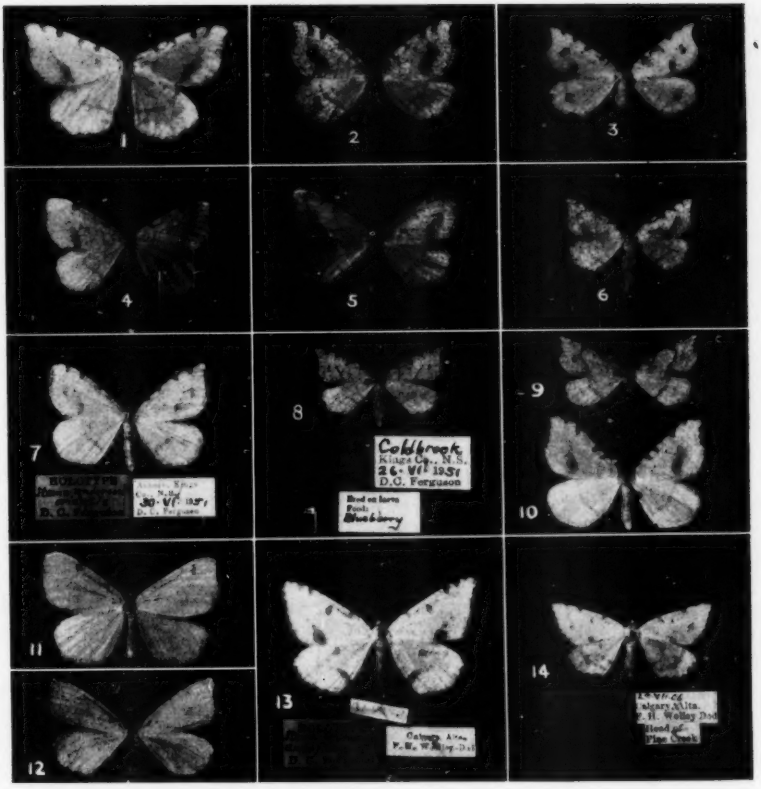
Range: Passadumkeag, Me. to Lakehurst, N.J., westward in the Adirondacks and at Horseheads, N.Y. In Canada seen only from Simcoe and Trenton, Ont., but recorded from Montreal by Forbes.

Flight Period: June 2-30.

Material Examined: 28 specimens.

Early Stages: Larva on *Vaccinium*.

Remarks: When it first became evident that the common *Vaccinium* feeding species in Canada was referable to *andersoni* and not *argillacearia*, there arose the question: Was *argillacearia* correctly identified? Although the type was not available for study, Dr. A. E. Brower kindly furnished a few specimens from Augusta, Me., about 30 miles north of the type locality, and these proved to belong to the smooth gray, almost immaculate species of the north-eastern U.S.,



All figures natural size. *Photographs by the author.*

1. *Itame occiduaria* Pack. ♂. Windermere, Upper Columbia River, B.C. (Wolley-Dod).
2. *Itame occiduaria* Pack. ♂. Grand Bend, Ont.
3. *Itame occiduaria* Pack. ♀. Riding Mountain Park, Man.
4. *Itame andersoni* Swett ♂. Wagon road between Whitehorse and Dawson, Y.T.
5. *Itame andersoni* Swett ♂. Cameron Bay, Great Bear Lake.
6. *Itame andersoni* Swett ♀. Cameron Bay, Great Bear Lake.
7. *Itame andersoni orientis*, new race, holotype.
9. *Itame andersoni orientis*, new race, ♀. Caraquet, N.B.
10. *Itame andersoni orientis*, new race, ♂. Constance Bay, Ont.
11. *Itame argillacearia* Pack. ♂. Augusta, Me.
12. *Itame argillacearia* Pack. ♀. Horseheads, N.Y.
13. *Itame sulphurea amboflava*, new race, holotype.
14. *Itame sulphurea amboflava*, new race, allotype.

rather than the smaller, more heavily marked Canadian population. In addition, Packard's description and figure leave little doubt about the identity of *argillacearia*.

The identity of *olivalis* Hulst still remains uncertain, since the type is not available for study. If it is in the same condition as certain other Hulst types, however, it is entirely likely that the true identity of *olivalis* will forever remain a mystery, since determining a single specimen without locality in this group, especially if it is a somewhat atypical example (as *olivalis* probably is), is no

simple problem. I leave it, as placed by Barnes and McDunnough ("Contributions", Vol. III, 3, p. 183), as a probable synonym of *argillacearia*. *Modestaria* Hulst is a *nomen nudum* (McDunnough, Can. Ent., Vol. 56, p. 274, 1924), and *inceptaria* Wlk., a name formerly associated with this species, rightfully belongs to *Philometra metonalis* Wlk. (McDunnough, Can. Ent., Vol. 65, p. 204, 1933).

***Itame sulphurea* Packard**

On studying material of *Itame* belonging to the Canadian National Collection, I was impressed by the size and coloring of the western examples of *sulphurea*, as compared with the more normal eastern specimens in the Nova Scotia Museum of Science collection. I describe the western population as follows.

***Itame sulphurea amboflava* new race**

Male. Ground color yellow as in the female, giving it an appearance totally unlike the gray eastern males. Fringes solidly brown, contrasting quite sharply with the yellow ground. Three wedge-shaped brown patches on the costa of the primaries near the apex and a fourth, less triangular, about 4 mm. from the base. Course of the t.p. line scarcely marked, except where it expands into a conspicuous brown patch near the inner margin. Another brown patch occupies a corresponding position near the inner margin of the hind wing. Brown discal spots on both wings large and distinct. The few brown scales sprinkled through the yellow ground tend to be lined up, giving a striate rather than a dusted effect. Most markings on the underside reduced, but the entire undersurface is much more heavily striate than above. Antennae, head, thorax and abdomen unicolorous brownish-cream or dull yellowish. 30 mm.

Female. Similar to the male but costal markings, discal spots and striations reduced. Brown patch near the inner margin on the primaries also reduced, but the corresponding patch on the secondaries is produced into a complete band, or rather a connected series of brown spots traversing the wing. Part of a second band also shows near the inner margin. Most of the markings beneath are intensified, and the primaries beneath show a well defined submarginal band, also in the form of a connected series of spots. 25 mm.

Holotype—♂, Calgary, Alta., July 31, 1907 (F. H. Wolley-Dod).

Allotype—♀, Head of Pine Creek, Calgary, Alta., July 25, 1906 (F. H. Wolley-Dod).

Paratypes—10 ♂ ♂, Calgary, July 24, 1901, July 29, 31, 1907 (Wolley-Dod); Lethbridge, Alta., July 5, 1923, Aug. 26, 1922 (H. L. Seamans); Swift Current, Sask., Aug. 20, 23, 1939 (A. R. Brooks); Shingle Creek Road, Keremeos, B.C., June 27, 1936, July 15, 1935 (A. N. Gartrell); Keremeos, B.C., Aug. 2, 1923 (C. B. Garrett). 2 ♀ ♀, Calgary, Alta., Aug. 17, 1893 (Wolley-Dod); Swift Current, Sask., Aug. 20, 1939 (A. R. Brooks).

Types Deposited: Holotype, allotype and eight paratypes to the Canadian National Collection, 2 paratypes in the Nova Scotia Museum of Science collection and one each to the collection of Mr. John L. Sperry, Riverside, Calif. and to the American Museum of Natural History, N.Y.

Range: Southern Manitoba to Vancouver Is. and northward to Rolla, B.C. and at Cut Knife and Harlan, Sask. The limits of its range southward are uncertain.

Flight Period: June 27-Sept. 20.

Early Stages: Unknown. The eastern race is commonly listed as a cranberry feeder, but apparently is not exclusively so. I bred a series, both males and

females, from larvae feeding in the spring on *Myrica gale* on a bog at Mt. Uniacke, N.S.

Material Examined: 28 specimens.

In Part II of the Lepidoptera of New York and Neighbouring States, p. 40, Forbes states that the eastern male is dimorphic and if Packard's description (Monograph of the Geometrid Moths of the U.S., p. 255) is to be relied upon, this must be so, although I have not seen the yellow male from farther east than Manitoba. When Packard wrote the description for the Monograph he apparently had only four specimens, supposedly two of each sex. The two females, from Brookline and Natick, Mass. had previously been made the types. Since no mention is made of a color difference in the males, one from Brooklyn, N.Y. and the other from Victoria, B.C., it is to be assumed that both were yellow. In the Maritime Provinces all the males appear to be of the gray variety, and these so closely match the males seen from Massachusetts that I would confidently expect to find this same situation prevailing with the topotypical population.

Packard first described the species as *Eupistheria sulphurea* (Fifth Rep. Peab. Acad. Sc., 77, 1873), and later in the Monograph (1876) redescribed it under the name *Thamnonoma sulphuraria*, mentioning in addition to the types, the Brooklyn, N.Y. and Victoria, B.C. specimens. This however does not render the name *sulphuraria* Pack. available for the western race since the change in ending was intended as a mere emendation, which cannot be considered to have any status distinct from *sulphurea*.

After he started describing Geometers, Packard discovered that the old custom had been to give species with pectinate antennae names ending in "aria", and those with simple antennae names ending in "ata". By the time he did the Monograph, he had acquired the two males of *sulphurea*, and finding that they had pectinate antennae, emended the name to *sulphuraria*.

Following in order after *ribearia* Fitch, *flavicaria* Pack. and *evagaria* Hlst., the species discussed in this paper may be listed thus:

1. occiduaria Pack.
2. andersoni Swett
   a orientis Ferguson
3. argillacearia Pack.
   modestaria Hlst.
   olivalis Hlst.
4. sulphurea Pack.
   sulphuraria Pack.
   s amboflava Ferguson

Notes on the Types of Some American Agromyzidae (Diptera)[1]

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It is unfortunate that Frick (1952), in preparing his generic revision of the Agromyzidae, was unable to examine the types of many species described by Loew, Malloch, Frost, and others. In such circumstances, a few mistakes were bound to be made, and the fact that these are not more plentiful is a tribute both to the quality of the descriptions of the authors concerned, especially Malloch, and to the care with which these descriptions have been analysed. In 1949, being interested in the possibility of using Hendel's (1931) European classification for the North American fauna, I examined 71 of the types in question, and was able without difficulty to reconcile most of them with Hendel's generic and subgeneric concepts. Of these types, only 13 are now found to conflict with the assignment proposed for the species by Frick.

In the notes that follow, the location of the type is placed in brackets after the name of the species. The correctly placed species are dealt with first and are arranged according to the revised classification. Following them is the list of disputed or doubtful species, and lastly there are five species of which I saw only paratypic or less authentic material. Some characters either additional to or modifying those given in the original descriptions are included in most cases. The phrase *fifth vein ratio* is used as a convenient means of denoting the relative lengths of the penultimate and ultimate sections of the fifth vein. For example, the ratio 1:2 means that the penultimate section is half as long as the ultimate. The figures are redrawn from free-hand pencil sketches of the types and are therefore, to some extent, diagrammatic.

Agromyza Fln. s. str.

A. abbreviata Mall., 1913 (United States National Museum).—3 + 0 *dc*; *ia* present; costa ending at third vein.

A. canadensis Mall., 1913 (U.S.N.M.).—*ia* present; costa between third and fourth veins present but very weak. The brown colour is normal for this species, the type being a fully developed specimen. In the Canadian National Collection are a male from Hawkeston, Ont., and a female from Ottawa.

A. currani Frost, 1936 (American Museum of Natural History), Fig. 3.—Third vein ending much closer to wing-tip than fourth vein.

A. diversa Johns., 1922 (Museum of Comparative Zoology).—The female from Chester, Mass., is labelled "holotype". 4 *fro*; lunule sunken below the frontal plane, silvery; cheek narrow, height posteriorly about one-eighth that of eye; 4 + 0 *dc* decreasing anteriorly; third vein closer to wing-tip than fourth vein; fifth vein ratio 3:2. The allotype has the fifth vein ratio 2:1. In the Canadian National Collection is a female from Simcoe, Ont., which differs in having the lunule pale brown and not sunken.

A. dubitata Mall., 1913 (U.S.N.M.).—3 + 0 *dc*; *ia* present; wing long, costa beyond the fracture very much broadened for a considerable distance, continuing to fourth vein; fifth vein ratio 3:2. The type series are all females. The end of the first vein is distinctly sinuate, but in several specimens is not totally appressed to the costa beyond the fracture. There is, however, no doubt that the species

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is correctly placed here. It seems likely that several closely related species are at present confused with it.

A. fragariae Mall., 1913 (U.S.N.M.).—The type is a male. Height of cheek posteriorly one-fourth that of eye; 3 + 1 *dc*, anterior pair stronger than usual; third and fourth veins equidistant from wing-tip; fifth vein ratio 5:4.

A. inaequalis Mall., 1914 (U.S.N.M.).—The specimen labelled "type" is a female. Malloch designated one of three males as type. The head profile and wing are well shown in Walton's drawing.

A. iridescens Frost, 1936 (A.M.N.H.), Fig. 3.—Anterior tibia with a posterior bristle at middle as in *currani*. Third vein ending much closer to wing-tip than fourth vein.

A. isolata Mall., 1913 (U.S.N.M.).—Height of cheek posteriorly one-sixth that of eye; *ia* present; costa continuing to fourth vein but weakened beyond third.

A. kincaidi Mall., 1913 (U.S.N.M.).—The head of the type has been broken off and is attached to the label with glue. 4 + 0 *dc*; *ia* present; fifth vein ratio nearly 2:1. The paratype has the head shrunken but shows the cheek very broad posteriorly as in the description. It has the fifth vein ratio about 3:2, and has also, perhaps, 1 presutural *dc*. Three specimens from Indiana and New Hampshire, standing under this name in the U.S.N.M. collection, seem to be of a different species.

A. parvicornis Lw., 1869 (M.C.Z.).—The type male (?) is destroyed except for one wing and two legs. The female is in good condition. Frons and antenna brown, frontal vitta swollen above lunule; cheek dark brown, height posteriorly over one-third that of eye; oral margin narrowly black; buccal membrane dark brown. 4 *fro* (4 on one side, 3 plus 1 hair on the other); 3 + 0 *dc* (anterior post-sutural bristle very weak); *ia* and *prsc* present; third vein closer to wing-tip than fourth; fifth vein ratio nearly 2:1. A male in the U.S.N.M. from Lafayette, Ind., has 5 fronto-orbitals and the anterior post-sutural dorsocentral bristle stronger but is not otherwise noticeably different.

A. setosa Lw., 1869 (M.C.Z.), Fig. 5.—The specimen labelled "type" is a male. Loew gave the type as a female. It is a large species, 3½ mm. long. Frons long, bluish-black, parafrontals not differentiated from frontal vitta; lunule yellowish-white; posterior surface of anterior tibia without strong bristles but two or three bristles at middle of postero-ventral surface of mid-tibia. 4 strong *fro*. Unfortunately I made no further notes on the specimen, but sketched the head-profile.

A. varifrons Coq., 1902 (U.S.N.M.).—The type is a female.

A. viridula Coq., 1902 (U.S.N.M.).—The type is a female labelled 'D. C. June. Coquillett.' Head like *posticata* M. Lunule shining white; antennae separated by half their basal width. 4 *fro*; 2 + 0 *dc* (widely spaced, the anterior closer to transverse suture than to the posterior); *ia* and *prsc* present; costa continuing to fourth vein; third vein a little closer to wing-tip than fourth.

Melanagromyza Hend.

A. angelicae Frost, 1934 (U.S.N.M.).—As indicated by the description, the parafrontals and parafacials are broad and very noticeable in profile view, and the antennae are widely separated.

A. angolae Mall., 1934 (U.S.N.M.).—The species is evidently close to *burgessi* Mall.

A. burgessi Mall., 1913 (U.S.N.M.).—The type series are all females. The species exhibits a condition found in several species of *Melanagromyza*. The

lunule is rather large, and, because of the widening of the parafrontals above the antennae, its sides are somewhat sinuate as in *Phytobia* (*Poemyza*). However, the upper margin is broadly rounded and there is a distinct median sulcus extending down between the antennae, which are slightly separated. 2 + 0 *dc*; *ia* present; *prsc* absent; costa continuing to fourth vein but weak beyond third; fifth vein ratio 4:3.

A. caerulea Mall., 1913 (U.S.N.M.).—Lunule large; antennae separated by half the width of one antennal socket; frons evenly curved into facial plane; fifth vein ratio nearly 2:1.

A. eupatoriae Mall., 1915 (U.S.N.M.).—The type specimen is a male that has the halteres missing. The position of the species is established, however, by Malloch's description and by the presence of these organs in the paratypes.

A. gibsoni Mall., 1915 (U.S.N.M.).—A slight carina present between antennae. The species has a very evident greenish metallic sheen. The type series are all females, but there are in the U.S.N.M. collection some topotypic males collected by Aldrich.

A. orbitalis Frost, 1936 (A.M.N.H.).—In this species, although there is no facial carina, an approach to the genus *Ophiomyia* Brasch. is suggested by a slight angulation at the vibrissae and by the presence of a strong median sulcus in the rather high lunule.

A. plumiseta Mall., 1913 (U.S.N.M.)

A. salicis Mall., 1913 (U.S.N.M.).—Parafrontal and parafacial broad and conspicuous in profile view; lunule high, lying in facial plane; antennae separated

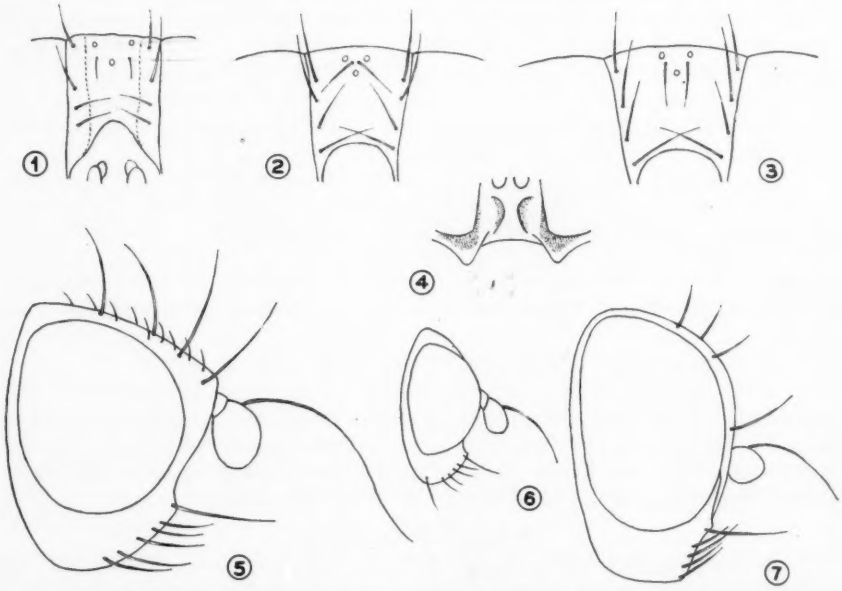

Fig. 1. *Phytobia* (*Poemyza*) *angulata* (Lw.). Frons, anterior view. Fig. 2. *Phytobia* (*Phytobia*) *dorsocentralis* (Frost) and *kallima* (Frost). The same. Fig. 3. *Agromyza currani* Frost and *iridescens* Frost. The same. Fig. 4. *Phytobia* (*Icteromyza*) *longipennis* (Lw.). Face and cheeks, anterior view showing dark pattern. Fig. 5. *Agromyza setosa* Lw. Head in profile. Fig. 6. *Phytobia* (*Poemyza*) *marginata* (Lw.) The same. Fig. 7. *Melanagromyza virens* (Lw.). The same.

at bases; 3 + 0 *dc*; *ia* present but small; *prsc* absent. The type male lacks both wings. This is the only specimen mentioned by Malloch and, in his drawing of the wing, he distinctly shows the costa ending just beyond the third vein. There are, however, two other specimens in the U.S.N.M. collection apparently from the same lot as the type. These have the fifth vein ratio 1:1, as given by Malloch, but the costa is continued to the fourth vein. Since Malloch omitted mention of this character in his description, but illustrated it very clearly in his figure, it seems certain that the condition of the wing in the type was as he showed it. If the other specimens belong to the same species, it can be inferred that this character is variable, at least in some cases.

A. simplex Lw., 1869 (M.C.Z.).—The type is destroyed. The bare pin bears only Loew's label, "*simplex m.*", and a note by Banks, "Gone when I came". From the description it must be placed here.

A. tiliae Coud., 1908 (U.S.N.M.).—The species is represented by a series of cotypes.

A. virens Lw., 1869 (M.C.Z.), Fig. 7.—The types are two females, one labelled "Penn." Frons strongly convex in profile; lunule sunken, the upper margin rounded; antennae separated by a very slight ridge; a small papilla at the vibrissal angle; lower anterior margin of cheek noticeably angulate; 4 *fro*, the anterior one distant from the others; orbital hairs numerous, mostly proclinate but the outermost row reclinate.

A. websteri Mall., 1913 (U.S.N.M.)

A. winnemanae Mall., 1913 (U.S.N.M.).—This is a problematic species. The condition of the apical parts of the auxiliary and first veins is intermediate between those of the coalescent and separated types (*Agromyzinae* and *Phytomyzinae* of Frick). The black halteres suggest *Melanagromyza*, as do also the profile of the face, narrow cheeks, and lack of presutural dorsocentral bristles. 2 + 0 *dc*; *ia* present; *prsc* absent; costa continuing to just beyond third vein; fifth vein ratio a little less than 1:1. It is probably correctly placed here, but the single female specimen by which it is at present known does not exclude *Ophiomyia* from consideration.

Ophiomyia Braschn.

The characters of this group are so well defined that species can usually be assigned to it without difficulty. The types of the following species are in the U.S.N.M. I have added merely the sex of the type as this is in some cases doubtful from the original description.

A. affinis Mall., 1913, ♀. *A. coniceps* Mall., 1915, ♀. *A. insularis* Mall., 1913, ♀. *A. texana* Mall., 1913, ♂. *A. vibrissata* Mall., 1913, ♂.

Phytobia Lioy (=*Dizygomyza* Hend.)

Subgenus *Phytobia* s.str. (=*Dendromyza* Hend.)

A. aceris Greene, 1917 (U.S.N.M.).—The first vein ends very close to the costal fracture, and the auxiliary vein lies parallel and very close to it throughout the distal half.

A. amelanchieris Greene, 1917 (U.S.N.M.)

A. kallima Frost, 1936 (A.M.N.H.), Fig. 2

A. pruinosa Coq., 1902 (U.S.N.M.).—The type is a male. The other specimens standing under this name in the U.S.N.M. collection appear to be of a different species.

A. taeniola Coq., 1904 (U.S.N.M.).—As indicated by Malloch (1913), this species is the same as *A. posticata* M. There are specimens in the Canadian

National Collection from numerous localities in Quebec and Ontario and from Aweme, Man.

Subgenus *Poemyza* Hend.

A. angulata Lw., 1869 (M.C.Z.), Fig. 1.—A male and female, of which the latter should be considered the type. Frons rounded into facial plane; lunule almost as high as the distance from its upper margin to anterior ocellus, somewhat silvery in oblique view; parafrontals and parafacials not visible in profile view, the former pale brown, rather wide; frontal vitta well differentiated, sunken, its surface overlaid with minute black spinules; bases of antennae separated, third segment small; cheek narrow; *ocs* parallel, their bases wide apart, directly below lateral ocelli; 3 + 1 *dc*; *ia* present; a small pair of presutural acrosticals; hairs of mesonotum rather long and erect; costa continuing to fourth vein, the latter ending closer to wing-tip than the third; fifth vein ratio 1:1.

A. coquilletti Mall., 1913 (U.S.N.M.).—Auxiliary and first veins very close together, the latter ending near the costal fracture; *ia* present. This distinctive species is represented in the C.N.C. by specimens from several localities in western Ontario, Manitoba, Saskatchewan, and Alberta. It is evidently rare in the East and there are only two specimens from Quebec (Montreal). The male has a broad, transverse keel protruding from the basal segment of the hypopygium above the cerci.

A. inconspicua Mall., 1913 (U.S.N.M.).—According to Malloch the type is a male, but the specimen labelled "type" and bearing the data given by Malloch is a female.

Subgenus *Icteromyza* Hend.

A. longipennis Lw., 1869 (M.C.Z.), Fig. 4.—Frontal vitta brown, sparsely covered with minute spinules; lunule yellowish, large, its height equal to distance from its upper margin to anterior ocellus; face short, yellowish, sutures conspicuously darkened; cheek yellowish, darkened along ventral margin of eye; femora yellow on apical third; fourth vein ending just behind wing-tip; fifth vein ratio 1:1. It is likely that Malloch (1913) misidentified this species.

A. coloradensis Mall., 1913 (U.S.N.M.).—I place this species here because of its evident close relationship to *A. longipennis* Lw., but note at the same time that it has certain features suggestive of an affinity with *Poemyza*. Malloch subsequently listed it as a synonym of *A. genualis* Mel., and it is so treated in the U.S.N.M. collection.

Subgenus *Amauromyza* Hend.

A. abnormalis Mall., 1913 (U.S.N.M.).—The type locality is Washington, D.C., not Kansas as stated by Frick. In the C.N.C. are a male from Abbotsford, Que., and a female from Chatham, Ont.

Subgenus *Calycomyza* Hend.

A. coronata Lw., 1869 (M.C.Z.).—The type male from Pennsylvania has the head collapsed but shows the face black with yellow oral margin; height of cheek about one-fourth that of eye; fourth vein ending at wing-tip; fifth vein ratio 1:2.

A. meridionalis Mall., 1914 (Academy of Natural Sciences, Philadelphia). Apparently belonging here despite the almost entirely yellow frons, face, and antenna.

Subgenus *Praspedomyza* Hend.

A. citreifrons Mall., 1913 (U.S.N.M.).—The type is a female. Postsutural intra-alar area bare; fourth vein ending at wing-tip; fifth vein ratio 2:3. It appears to be different from specimens in the U.S.N.M. collection from Wooster,

Ohio, determined as of *A. clara* Mel. by Aldrich. The latter specimens have the postsutural intra-alar area haired.

Subgenus *Dizygomyza* Hend.

(Frick was unable to suggest the derivation of this name, but it seems to me that Hendel intended it to refer to the two separate junctions of the auxiliary and first veins with the costa.)

A. magnicornis Lw., 1869 (M.C.Z.).—The type has the mesonotal characters destroyed by the passage of the pin through the thorax, but it has apparently three strong *dc*, of which one is presutural. There are about six rows of acrostical hairs between the anterior *dc*. The following areas are yellow: notopleuron, humerus except mesally, narrow dorsal and posterior margins of mesopleuron, narrow posterior and lateral margins of abdominal segments one to four, haltere, apical sixth of femora, extreme base of tibiae; fifth vein ratio 4:5. Johnson's male from Tifton, Ga., standing under this name in the M.C.Z. collection, is of a different species. His male from Manayunk Pa. is of a third species.

Liriomyza Mik

A. borealis Mall., 1913 (U.S.N.M.).—The data for the type, which was omitted from the original description, is: "Bear Lake, B.C., 20.7.03, Caudell."

A. flavonigra Coq., 1902 (U.S.N.M.).—The type is a female.

A. longispinosa Mall., 1913 (U.S.N.M.).—Orbital hairs absent; 2 *ia* present, placed further forward than usual, the posterior one stronger. Malloch subsequently placed this as a synonym of *A. pacifica* Mel., which is evidently correct as both authors used, in part, material from the same collections. The type of *longispinosa* agrees very closely with a paratype male of *pacifica* (Brodie Coll.) in the U.S.N.M.

A. melampyga Lw., 1869 (M.C.Z.).—The head of the male is missing. Abdomen black with narrow posterior margins of segments one to four yellow; rest of body yellow except the mesonotal vittae, postscutellum, and a large patch on sternopleuron. The female agrees with the male, but the abdomen is all yellow except for the shining black ovipositor. Occiput, except a fairly broad band along the eye-margin, black; height of cheek posteriorly one-quarter that of eye; 4 *fro*, anterior two only a little incurved; fourth vein ending only a little behind wing-tip; fifth vein ratio 8:9.

A. picta Coq., 1902 (U.S.N.M.).—The type is a female. *ia* present.

A. quadrisetosa Mall., 1913 (U.S.N.M.).—Strong *ia* present.

A. schmidti Ald., 1929 (U.S.N.M.)

Haplomyza Hend.

Phytomyza palliata Coq., 1902 (U.S.N.M.).—The type is a female. According to my notes the species seems typical of *Liriomyza* except for the absence of the posterior cross-vein. It does not run out to *Xeniomyza* in Hendel's (1931) key to genera, which I was using for this study, and I therefore accept Frick's placement of it in *Haplomyza*.

Napomyza Westw.

A. davisii Walt., 1912 (U.S.N.M.).—The type is a female.

A. parvicella Coq., 1902 (U.S.N.M.).—The type is a female.

Doubtful Species

The following species, in my opinion, either do not belong to the group to which they are assigned by Frick, or are of doubtful enough generic position to warrant further study.

A. congregata Mall., 1913 (U.S.N.M.).—The slight carina and close-set group of bristles at the vibrissal angle suggest that this species is intermediate between *Ophiomyia* and *Melanagromyza*. Although the typical members of each of these genera may present characters that are distinctive enough, other species are found both here and in the Palaearctic region which tend to erase any sharp definition of the limits between them. Five specimens of both sexes from Colorado in the U.S.N.M. are evidently of this species. Frick places it in *Ophiomyia*.

A. discalis Mall., 1913 (U.S.N.M.).—*Pvt* present; orbital hairs mostly upright, slightly proclinate anteriorly; 3 + 2 *dc*, anterior one small; acrostical hairs absent; fourth vein ending before wing-tip; fifth vein ratio 1:4. On the basis of the above characters, I place it, with some doubt, in *Phytoliriomyza*, which Hendel treated as a subgenus of *Liriomyza*, but which Frick accords generic status. I note that it falls outside Frick's concept of *Phytoliriomyza* because of the absence of acrostical hairs. On the other hand, the course of the fourth vein places it outside Hendel's concept of this group. Frick places it in *Liriomyza* s.str.

A. dorsocentralis Frost, 1936 (A.M.N.H.), Fig. 2.—This species is closely related to *kallima* Frost and belongs in *Phytobia* (*Phytobia*) despite the yellow scutellum. Parafrontals not differentiated from frontal vitta; lunule silvery; *ia* present; *prsc* absent. Frick places it in *Agromyza* s.str.

A. imperfecta Mall., 1934 (U.S.N.M.).—This species goes to the subgenus *Phytoliriomyza* in Hendel's (1931) key. Frick places it in *Liriomyza* s.str.

A. indecisa Mall., 1913 (U.S.N.M.).—A species of doubtful position. Evidenlty in *Phytobia*, perhaps belonging to the subgenus *Praspedomyza* or, less probably, to *Cephalomyza*. Frick leaves it unplaced subgenerically.

A. longiseta Mall., 1913 (U.S.N.M.).—The type has several unusual features and I refer it to *Melanagromyza* (where Frick places it) with some doubt.

A. maculosa Mall., 1913 (U.S.N.M.).—The type is a female. Height of cheek posteriorly one-quarter that of eye; anterior *dc* placed well in front of suture; *ia* present; third and fourth veins equidistant from wing-tip; fifth vein ratio 5:4. I refer the species to *Phytobia* (*Amauromyza*) with some doubt as to the subgeneric placement.

A. marginata Lw., 1869 (M.C.Z.), Fig. 6.—Frontal vitta sunken, covered with minute spinules; parafrontals strongly differentiated, wide, clay-yellowish; lunule high, reaching halfway to anterior ocellus; 4 *fro; ocs* very short, hairlike; height of cheek posteriorly one-quarter that of eye, clay-yellow to brownish; 3 + 0 *dc*; *ia* present. The species belongs to *Phytobia* (*Poemyza*), not to the subgenus *Dizygomyza* as stated by Frick.

A. minima Mall., 1913 (U.S.N.M.).—Frick lists this species as a synonym of *Ophiomyia maura* (M.), quoting MS notes of Melander as his authority. I cannot accept the synonymy in the face of Malloch's description and the appearance of the holotype male, which has neither a carinate face nor a fascicle of bristles at the vibrissal angle. I place it in *Melanagromyza*.

A. neptis Lw., 1869 (M.C.Z.).—Loew mentioned a specimen of each sex, but under this name I found only a female, which therefore must be considered the type. It bears no locality label, and this is apparently proper for Osten Sacken's District of Columbia material. It belongs to *Phytobia* (*Poemyza*), is very similar to the type female of *angulata* Lw., and is possibly of the same species although it is a smaller specimen (about 1.5 mm.). Frick places it in *Agromyza* s.str.

A. nitida Mall., 1913 (U.S.N.M.).—Orbital hairs are very difficult to observe in this species and, if present, they must be very fine and pale. Malloch's drawing of the wing suggests that the species would be properly placed in *Phytagromyza*

and examination of the type confirms this. A male from White Heath, Ill., Aldrich coll., is evidently of the same species. It lacks intra-alar bristles. Frick placed the species in *Agromyza* s.str.*

A. ulmi Frost, 1924 (U.S.N.M.).—A problematic species. I place it provisionally in *Agromyza* s.str. on the basis of the wing venation and despite the long postero-ventral extension of the cheek. 3 + 2 *dc*, decreasing in length anteriorly; fine *ia* present; costa ending halfway, or less, between third and fourth veins, which are equidistant from wing-tip; fifth vein ratio 3:2. A (headless) male paratype of *A. aristata* Mall. in the U.S.N.M. collection is of the same species.

A. waltoni Mall., 1913 (U.S.N.M.).—Lunule semicircular, lying in facial plane; bases of antennae separated from each other by a distance equal to the thickness of one of them; 3 + 1 *dc*; *ia* present; auxiliary vein lying very close to first vein, the latter enlarged apically and joining costa very close to the fracture; costa continuing to fourth vein, the latter ending behind wing-tip; fifth vein ratio 2:3. I place it in *Phytobia* s.str. with some doubt.

The following five species are represented in the U.S.N.M. collection by paratypic or less authentic material, the types being in European museums.

A. arctica Lundb., 1900.—A male from Greenland (No. 6191889), determined by Lundbeck, belongs to Hendel's concept of *Phytoliriomyza*.

A. chilensis Mall., 1934.—A female from Casa Pangue, labelled "allotype", belongs to *Liriomyza*.

A. maculosa var. *fuscibasis* Mall., 1934.—A male paratype from Bariloche belongs to *Phytobia* (*Amauromyza*).

A. nitidiventris Mall., 1934.—A paratype from Bariloche, with abdomen missing, belongs to *Phytobia* (*Dizygomyza*).

A. peullae Mall., 1934.—A male paratype from Casa Pangue belongs to *Phytobia* (*Praspedomyza*).

Several other Malloch species, collected during the Edwards and Shannon Expedition to Patagonia in 1926, are represented by "paratypes" in the U.S.N.M., but as the data on these specimens conflicts with that given in the description, I omit mention of them.

Acknowledgments

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Polythene-stoppered Vials for Storing Insects in Alcohol

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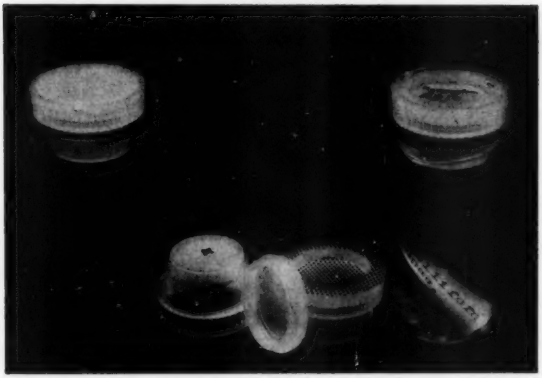
Many attempts have been made to overcome the difficulties attendant upon storing insect material over extended periods of time in small vials of alcohol. Cork stoppers fail to meet requirements for various reasons, while their substitution with rubber ones may introduce still further complications. Both are liable to shrink or to swell while either may be forced out of the vials as a result of variations in room temperature. In addition, neither can be readily marked in such a manner that the contents of the vials are permanently and plainly legible from above.

It is doubtful whether any type of stopper can overcome all hazards of long-time storage, particularly when stoppers must occasionally be removed for a close study of the vial contents. Most of these have, however, been greatly reduced by the method of storage which has been in use at this University during the past four years.

All insect material, as individual specimens or when in small numbers, is stored in vials of approximately five to eight dram capacity, fitted with the two-piece polythene stoppers which are now available from several sources. As supplied, however, these stoppers still suffer from the effects of temperature variations and a percentage of them may ultimately be forced part-way out of the vials with a consequent rapid loss of alcohol.

This trouble can be overcome by punching a very small hole in the centre of the lower wall of the stopper and another through its side-wall close to the upper rim that surrounds it. No. 0, or No. 1 insect pins are well-suited to this purpose. When a stopper so treated is inserted into a vial the hole in the side-wall is closed by the glass and it may remain permanently in this position. If, however, pressure in the vial raises the stopper it will do so only so far as is necessary to expose this minute hole. This, of course, will allow a certain amount of alcohol vapour to escape every time the temperature of the vial is raised if, at at any previous time, it has already unseated the stopper. A series of vials, half-filled with alcohol, were placed where they would be exposed to direct sunlight



Left to right:—1. Vial as purchased. 2. Lower half of stopper, crosses indicate where a fine pin should be inserted. 3. Top half of stopper. 4. Stopper with top half in reversed position. The stippled area shows where the surface should, ultimately, be flooded with lucite dissolved in ethylene dichloride. 5. Vial ready for storage. (Photograph by B. Hocking.)

daily for a period of three months. At the end of this period several untreated stoppers had been driven sufficiently far out of the vials to break any sealing effect and most of the alcohol had evaporated. Though a similar number of the treated stoppers had risen far enough to expose the "escape" hole, in none of these vials had there been an appreciable loss of alcohol. Naturally, in both instances, conditions had been far more drastic than any which would result from more normal storage in a cabinet.

A second problem to be overcome is that of effective labelling. Originally it was considered that, by turning the removable disc of this type of stopper upside-down, in order that its original lower surface would lie at about ⅛ inch below the surrounding rim, anything written here with India ink would prove to be permanent. Polythene takes ink readily but it was soon discovered that many people who handle these vials cannot resist the urge to insert a finger into this depression and to rub it around until any writing on it is rendered illegible. This defect was overcome by liberally flooding this area, after the ink has dried, with a saturated solution of lucite in ethylene dichloride. Though this does not actually bond with the polythene, upon drying out it forms an impervious coating the removal of which requires more industry than a succession of casual handlers are prepared to expend. At the same time, the "suture" between the two parts of the stopper must, also, be well flooded with the solution in order to seal it effectively. It is advisable to do this after the stopper has been inserted into the vial and while the latter is grasped in a closed hand. Expansion in the vial, which is thus slightly warmed, causes bubbles to appear in the solution over any still existing leak but, as the vial returns to room temperature, the solution is drawn into these areas and it seals them effectively.

Very few stoppers have been found which do not make a reasonably tight seal when they are inserted into the vials. The combination of a vial and stopper in which the latter, when turned by hand, moves with little or no friction should, however, be avoided, and it is always advisable to store vials in an upright position.

When stoppers are purchased in quantity, it is advisable to avoid brands on which the manufacturer has chosen the underside of the disc for inscribing raised figures or letters since these interfere with legible writing when the disc is placed in its reversed position.

The Influence of Spray Programs on the Fauna of Apple Orchards in Nova Scotia. IV. A Review[1]

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Introduction

Studies on the ecology of the fauna of apple orchards in Nova Scotia were initiated in 1943, to determine the long-term influence of spray chemicals on the populations of apple-infesting insects. At that time it was felt that the indiscriminate use of spray chemicals in the control of orchard pests was sometimes creating worse problems than those corrected—and was threatening the economy of apple production; and that there was an urgent need to determine, if possible, how to harmonize biological and chemical control. A more comprehensive discussion on the biological and philosophical concepts on which the studies were based may be found elsewhere (Pickett *et al.*, 1946; Pickett, 1949a; 1949b).

A vigorous attempt has been made to adapt ecological methods to chemical control studies so that the direct and indirect effects of the sprays on the orchard fauna might be clarified. To examine all the ramifications in the disturbances in the balance of animal populations brought about by the introduction of a spray chemical into an environment is a vast project indeed. Within the practical limits governed by staff and facilities this has been attempted in our work for the past few years. The practical results summarized in this paper show not only that the studies have modified spray practices in the Annapolis Valley but also that the spray practices in turn are having an influence on the trends of the studies.

It is not intended to imply that the particular combination of natural and artificial control that may be effective under conditions in Nova Scotia will produce similar results elsewhere. Those of us engaged in this work are of the opinion that economic entomologists must realize that they are dealing with living things, which may vary from one area to another, and, furthermore, that their work must be more than simply insecticide testing or a quest for highly destructive chemicals.

Recent papers by a number of prominent entomologists have emphasized the importance of a comprehensive approach to the whole question of insect control. Notable among those who warn that we must not indiscriminately interfere with the balance of insect populations are Ullyett (1951), Wigglesworth (1950), DeBach (1951), Griffiths (1951), and Wille (1951). A. W. A. Brown (1951) has also stated the case lucidly.

Comprehensive studies on the ecological relationships of the species involved and on the immediate and long-term consequences of artificial controls are the only alternatives to costly interference with the forces of nature. As Wigglesworth (1950) has pointed out, it is sometimes through the activities of the entomologist himself that entomological problems arise. The empirical methods that economic entomologists have been obliged to use are frequently of dubious value and should be considered as temporary measures that must be continuously re-examined. It is easy to say that this or that should or should not have been done, but the fact remains that at no place in the world have

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the necessary facilities been available to carry on the very extensive and intensive research programs necessary to give proper insight into the phenomena with which we are dealing. Our own feeble attempts are but a drop in the bucket.

As has been so well illustrated by Graham (1951), the fundamental problem of the economic entomologist is to obtain an understanding of the dynamics of insect populations. There is obviously no single factor determining insect density and the entomologist is always faced with the question as to whether the population of the species with which he is dealing will increase or decrease in the immediate future. Since he frequently has no sound basis for determining the answer to this problem, he decides not to take a chance on a natural reduction and advises the grower to apply remedial measures. If the results of the treatment are satisfactory the grower will probably continue the treatments as insurance against future outbreaks until finally the species develops resistance to the insecticide or the natural enemies of the pest are so decimated that more and heavier treatments are necessary.

Methods of Study

These studies are largely ecological, the main emphasis being placed on field projects and laboratory and insectary studies when possible. Attempts are made, to the extent of our resources, to study pest populations and their natural enemies at different population densities and to determine, where possible, the factors involved in population dynamics.

The orchards selected for carrying out the tests had diverse characteristics. Some had high and some had low populations when the investigations were begun. Some orchards were treated as units, and others were divided into plots. The treatments were usually continued for a number of years. Wherever possible, the specific influence of each chemical is studied separately.

It is obvious that the number of orchards that can be treated by our own staff is limited. To offset this handicap we have persuaded a number of growers to co-operate with us. These growers spray their orchards without any assistance from us but follow a schedule we recommend. This is a distinct advantage since it gives a much broader view of the general effects of each spray combination and accelerates greatly the progress that can be made. We consider this co-operation with growers an essential feature of our research program. We are able not only to increase the kinds of treatments applied but also to observe the results under combinations of circumstances that would be impossible otherwise.

Under the climatic conditions of Nova Scotia, apple scab, *Venturia inequalis* (Cke.) Wint., is a serious problem and fungicides must be used extensively. Consequently, a great deal of time has been spent in testing the influence of fungicides on insects since it is believed that the use of some of them increases the survival potential of some of the more important pests.

Preliminary tests with insecticides on specific pests and beneficial species are carried out in small plots and extended to whole orchards when the initial results justify it. Probably the most important feature of our work is that we consider the whole fauna and attempt to record the population changes that occur. Not only do we concern ourselves with the population dynamics of pests and known beneficial species but we include, in so far as our resources allow, what are usually considered innocuous or incidental species. Sometimes the latter may be important as food reservoirs for beneficial species. Moreover, we include, as far as possible, a study of all the species in the orchard

environment. What takes place outside the orchard may be as important as what happens inside: time and space are important factors in all ecological studies.

Results

In 1943, when these studies were undertaken, there were four pests of major importance in the apple orchards of the Annapolis Valley, viz., the oystershell scale, *Lepidosaphes ulmi* (L.); the European red mite, *Metatetranychus ulmi* (Koch); the eye-spotted bud moth, *Spilonota ocellana* (D. & S.); and the codling moth, *Carpocapsa pomonella* (L.). The history of these pests in Nova Scotia orchards has been outlined in other papers (Lord, 1947, 1949; Pickett, 1949a, 1949b). It is sufficient to state here that they were all known to exist in the area for many years but, except the eye-spotted bud moth, had only recently become of major importance. Brief references to each of these species indicate the results of the studies.

Oystershell Scale

This pest caused severe damage to hundreds of orchards and, from 1933 to 1945, many trees were killed. Within two years after these studies began it was demonstrated that the use of sulphur as a fungicide was the main factor causing population increases. The general use of copper and ferbam instead of sulphur allowed natural control factors to operate and brought about a prompt and spectacular reduction of the scale population. As a result of the elimination of sulphur from the spray program by the majority of growers, this pest is now of very minor importance in Nova Scotia. Since the scale has a low degree of mobility and has only two important natural enemies, it was a comparatively simple matter to determine the influence of biotic agents on its population status under the conditions prevailing in this area.

European Red Mite

Studies reported by Lord (1949) indicate that this pest has many species of predators, over 30 being listed. These studies have shown that many spray chemicals, particularly DDT and sulphur, are detrimental to some of the predator species, including the more important ones. This frequently accounts for the tremendous build-up in populations of the European red mite and other phytophagous species. The long-term studies have provided a basis that makes it possible to select spray programs that allow natural control of the phytophagous mites and, at the same time, provide adequate chemical control of injurious insects and diseases. Copper and glyoxalidine (Crag Fruit Fungicide) are satisfactory fungicides in this respect. Nicotine is a satisfactory insecticide in most instances but may sometimes reduce populations of beneficial species. The arsenicals appear to cause little trouble at times, particularly early in the season, but further information on timing is required.

Eye-Spotted Bud Moth

The results of our studies on this insect are not as definite as for the scale and the European red mite. There is ample evidence that DDT, parathion (Stultz, 1950), and the arsenicals, when used according to the general practice in the area, have an adverse effect on the natural enemies of this pest. The influence of the fungicides has not been clearly demonstrated but there is evidence that sulphur is detrimental to natural control. Orchards with low bud moth populations, and sprayed with fungicides relatively innocuous to biotic control agents, have not shown increases that would make this insect a pest of economic importance. Relatively low populations have persisted in these orchards although no insecticides have been applied for 14 consecutive years and fungicides only have been applied for the past nine years. Further-

more, in a great many instances where the bud moth populations have been high in orchards treated regularly with fungicides and insecticides, discontinuing the insecticides has resulted in a marked upsurge of biotic control agents which sharply reduce the pest populations.

Time and circumstances have not permitted us to demonstrate whether biotic factors alone may be depended upon to provide economic control of this pest over the whole of the Annapolis Valley area year after year. Nevertheless, the fact remains that the eye-spotted bud moth occurs in outbreak numbers only in sprayed orchards. This may be due to factors other than inadequate biological control.

Codling Moth

Like the eye-spotted bud moth, this insect is highly mobile, has a long life-cycle (only one full generation per year in Nova Scotia), and a low density compared with those of mites and scales. Time and other circumstances have militated against a final conclusion, but we have established with a reasonable degree of certainty that sulphur fungicides used extensively are detrimental to the biotic control factors. The predacious thrips *Haplothrips faurei* Hood and *Leptothrips mali* (Fitch), both active egg predators, are suppressed by this fungicide. Copper fungicides have been less detrimental in this respect. It has not been possible to test the organic fungicides extensively, but the glyoxalidine compound now in common use and ferbam have not shown any tendency to suppress the codling moth predators on which they have been tested. The latter material may suppress the fungus *Beauveria globulifera* (Speg.) Picard, which appears to be a fairly effective control agent under certain conditions.

It is well known that lead arsenate reduces the effectiveness of the parasite *Ascogaster quadridentata* Wesm. (Boyce, 1943; Cox and Daniel, 1935) and it also eliminates from the orchard fauna the predator mite *Anystis agilis* Banks. DDT and parathion are highly lethal to many species of the parasites and predators.

Although we are unable to say definitely at this time that it will be generally feasible, economically, to grow apples in Nova Scotia without resorting to the use of insecticides to control the codling moth, there are very definite indications that insecticide applications for this purpose may be kept to a minimum. We are operating five experimental orchards where sprays for this insect have not been applied for from four to 13 years; and in none of them has the damage from the codling moth at any time gone higher than 20 per cent and it has generally ranged from five to 15 per cent. Furthermore, as a reduction of the number of insecticidal sprays in this rather concentrated apple-producing area has decreased, the codling moth populations have tended to become less in these orchards.

In addition, a goodly number of growers have adopted a modified spray program, suggested by us, and some of them have had very satisfactory results. Some who had used DDT to reduce codling moth populations before adopting a modified program have had difficulty with codling moth increases during the second and third years of the modified program. This is probably due to a number of factors, including the almost complete destruction of beneficial species, the degree of isolation of the orchard from sources of beneficial forms and the destruction of large numbers of trees which forced the codling moths to move to new locations. On the other hand, a considerable number of orchards where DDT had been used and many where lead arsenate had been applied extensively were changed from an intensive to a modified spray

program without any serious consequences. After as many as four years on this program, many of these orchards are producing apples with less than 10 per cent total insect damage to the fruit. In some cases the spray schedule involves the use of no insecticides and in others one or two applications per year for such pests as aphids, tent caterpillars, or cankerworms. Some growers have been successful in reducing codling moth infestations with sprays containing fixed nicotine without seriously interfering with natural controls. Another material, ryania, used in 1953 for the first time in Nova Scotia for this purpose, shows considerable promise as a selective insecticide for codling moth.

Discussion

It would be idle to suggest that all of the problems connected with the control of orchard pests in Nova Scotia have been solved. Much remains to be done and one important problem is to convince the fruit grower that pest control is an involved biological problem that must be considered as a long-term proposition. As Ullyett (1951) has pointed out, we are not likely to attain 100 per cent freedom from damage with any program. The question arises as to what concession can be made to insect damage before chemical controls should be applied. There are so many angles to this question that it is impossible to give a final answer. We believe the fruit grower should concede the codling moth 20 per cent of his crop rather than engage in a DDT or an extensive lead arsenate control program with all of the attendant problems of increases in mites and insects, spray residues, reduced foliage efficiency, chemical residues in the soil, lowered fruit quality, hazards to personnel, and other possible complications. It may be we can pay even more than this in short crop years. One thing is certain: no one can prepare a completely reliable control program today, either with or without chemicals.

Many of the problems outlined by Morris (1951) in forest insect control are encountered by the entomologist working on fruit insects. The control program must be practical and adaptable to the particular conditions under which it will be used: to attempt to provide protection against every eventuality would bankrupt the grower. The control program must not only be designed to control the various pests but must also be integrated with general orchard practices and the other limitations imposed by nature and by economics.

Growers, and entomologists as well, must realize that if a shift is to be made from an extensive to a minimum insecticide program it can only be done at a price. We cannot destroy the biotic control agents by the indiscriminate use of chemicals and then expect to find the trees full of parasites and predators when we decide the chemical program is too costly. Also, as DeBach (1951) has pointed out, we cannot expect predators to continue to exist unless there is something for them to live on.

Much has been said about the possibilities of combining chemical and biological control through the use of systemic insecticides (Ripper, Greenslade, and Hartley, 1951), and no doubt there are possibilities of doing this in certain instances. However, we are dubious about the value of systemic insecticides for this purpose in a permanent type of plantation such as a fruit orchard.

Ripper, Greenslade, and Hartley (1951) have pointed out that in order to have combined chemical and biological control a selective insecticide must allow for the survival of sufficient individuals of the pest population to sustain an effective population of natural enemies. This appears self-evident, but we are unable to concur with their contention that this desirable result is likely

to be achieved through the use of systemic insecticides. According to these authors, the latter kill many species of phytophagous feeders, including aphids and mites.

It appears to us that effective populations of natural enemies cannot be maintained when the most important link in the food chain, the phytophagous feeder, is largely eliminated. Our investigations indicate the importance of general predators, even though experience has taught us the wisdom of Thompson's (1951) warnings against misleading rationalizations in this respect. There appears to be a good deal of evidence to indicate that phytophagous mites and aphids, both groups with tremendous reproductive potentials and of almost universal occurrence, provide the basic food reservoir for some species of predacious thrips, mirids, coccinellids, syrphids, chrysopids, and possibly others. If the former groups are suppressed over an extensive area, on what will the latter live?

It is true that many predators are highly mobile, and can re-establish themselves in small areas. In large areas, sometimes involving whole communities, and with repeated treatments over successive years, considerable changes in the relative numbers of species must surely result. If these general predators are sharply reduced, will this not increase the survival potential of the relatively low density pests such as the codling moth, leaf rollers, and bud moths? It may be that parasites would be more active if predators were reduced, but generally speaking, parasites appear to be more effective under higher pest density conditions than could be tolerated economically. As has been pointed out by DeBach (1951), general predators evidently are influential at lower pest densities. They may feed incidentally on certain pest species or may even prefer them when available. This may be one reason why such pests as bud moths and leaf rollers, for which there is almost always an ample food supply, are not more generally abundant in the absence of artificial controls. Our observations support this hypothesis.

Conclusion

There are great difficulties involved in combining biological and chemical control under field conditions. It is similar in many ways to the relationship between preventive and curative medicine. As Wigglesworth (1950) has stated, "The public loves the hospital, the doctor and the bottle of physic; while the advances in preventive medicine which have transformed our lives are scarcely noticed. So too it creates a greater impression on the mind to destroy an infestation of insects that can be seen, than by some simple change in practice to prevent any infestation from developing." Had the staff of our laboratory developed an insecticide that would control the oystershell scale as effectively as the mere changes in program that allowed nature to take its course, they would have been assured of a place in entomological history.

Nevertheless, this is a fertile field for investigation. We must search deeply into the ecological, physiological, and systematic relationships of the fauna to obtain a clearer concept of the dynamics of the phenomena. Carpenter (1950) has said, "Seemingly, scientists have been more interested to look inward and to dissect than to look out and to synthesize." We have been trying to do both but nature reveals her secrets slowly. Probably it is well that this is so: it constitutes a safeguard against impetuousness; and the unknown, even in research, adds a stimulus that is exhilarating.

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Book Reviews

APHIDS OF THE ROCKY MOUNTAIN REGION, by Miriam A. Palmer. 452 pages, 455 text figures, eight coloured plates. The Thomas Say Foundation, volume 5, 1952. $10.25.

This comprehensive volume treats the aphids of Colorado and Utah and bordering sections of Wyoming, Idaho, and New Mexico. Its usefulness is not restricted to workers of this area, however, because most of the economically important species occurring in the United States and Canada are included in it.

The introduction includes a brief discussion of the characters, life history, and economic importance of the Aphidae, directions for collecting and shipping them, and drawings depicting the structures used in their classification. The taxonomic portion of the book contains characterizations for, and keys to subfamilies, tribes, subtribes, genera, and species. It gives descriptions of 532 species, and has adequate illustrations and helpful mention of the chief distinguishing characters of most of them. A key to 224 species commonly infesting plants of economic value, arranged under their respective hosts, make up a subsequent section of the book. Common names accompany the majority of the scientific ones of this key and the same names are associated in the taxonomic treatment of the aphids. In addition the volume contains eight colored plates showing various forms of 32 species, a host plant list, a gazetteer of localities without Post Offices, a bibliography, and an index. The printing and illustrations are of fine quality, and the volume is well bound and of comfortable size.

This extensive work by a person of long experience in the study of this difficult group is helpful to any one having an interest in the Aphidae, and is of exceptional value to both taxonomic and economic workers.

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INSECT CONTROL BY CHEMICALS, by A. W. A. Brown. John Wiley and Sons Inc., New York. 817 pp. 1951. $12.50.

This is an outstanding and, in some respects, unique book on insecticides. The main facts and theories concerning toxic chemicals, solvents, diluents, emulsifiers, and spreaders, and their use in the control of insects, are presented in a clear and pithy style. It is a particularly valuable reference for entomologists and graduate students in toxicology and chemistry of insecticides. Other agricultural scientists will also find it a useful source book, although it does not, indeed could not in the space available, give details for the tremendous number of individual pest control problems.

This book is devoted almost exclusively to a treatment of the new, powerful, organic insecticides, and of modern equipment and methods in present-day use for the control of insects. The older insecticides, especially the inorganics such as arsenicals, are given only a small amount of space, and attractants and repellents are entirely omitted. Details are avoided, but these can be found in the very extensive lists of references given at the end of each chapter.

The first chapter briefly describes more than 100 practical insecticides, mostly organic materials, and their principal uses. The three following provide a valuable presentation of the toxicology of insecticides, including how toxic materials enter insects, how they act, and how various physical and biological factors influence their effectiveness. A discussion of 97 pages on the relationship of molecular structure to toxicity is an original contribution by the author.

Two chapters are devoted to modern equipment and methods used in the application of insecticides, one dealing with ground, the other with air-borne methods. The appraisal of aircraft application is especially valuable to the "air-minded". The influence of physical factors, e.g., droplet or particle size, weather conditions, on the dispersal and deposition of chemicals are discussed. Two chapters are devoted to the toxicity of insecticides to plants, man, and domestic animals. The chief practical uses of chemicals in insect control are presented in two chapters. This information is arranged by insect orders or smaller groups rather than by crop, host, or insecticide; and the relative effectiveness and approximate dosages of insecticides required for effective control, but not other details, are given. Finally, some of the effects of chemicals, chiefly DDT, on the faunal balance are discussed in the last chapter.

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